PRACTICAL VENTILATION AND WARMING.

CONSTANTINE.

ILLUSTRATIONS AND EXAMPLES.

PRACTICAL
VENTILATION AND WARMING.

PRACTICAL
VENTILATION AND WARMING.

PRINTED BY CHARLES E. SIMMS,
MANCHESTER.

DEDICATED TO

DR. ROBERT ANGUS SMITH, F.R.S., F.C.S., &c., &c., &c.,

AS A TRIBUTE OF THE RESPECT AND ADMIRATION IN

WHICH HE IS HELD BY THE AUTHOR.

Manchester,
May, 1881.

PREFACE.

THE Author having had his attention called to the subject of warming and ventilating large buildings, was surprised to find so little definite information available, and that until the last few years these matters were treated (more especially as to ventilation) as of very small consequence. Numbers of buildings have been erected where apparently the ventilation and warming have never been considered at all, and could only afterwards be arranged for by cutting and patching the finished structure.

It is not professed herein to set forth complete schemes of ventilation, but a number of illustrations are given of the means by which large buildings have been successfully dealt with, and this book is offered as a humble contribution to the present knowledge of these matters, with the hope that someone competent to deal with the whole subject may further develope it.

The Author desires to offer his grateful ac-knowledgements to the Architects who have so

kindly permitted the use of their drawings and so readily afforded him information; especially are these due to Messrs. BARKER and ELLIS, for plans of the Free Trade Hall, Manchester; Messrs. MILLS and MURGATROYD, for plans of the Royal Exchange; Messrs. SALOMONS and ELY, for plans of the Concert Hall; and Messrs. PENNINGTON and BRIDGEN, for plans of the Manchester Pantechnicon; and to Mr. F. R. BARKER, Architect, for valuable assistance with the book generally.

J. C.

Manchester,
May, 1881.

CONTENTS.

ILLUSTRATIONS.

CHAPTER I.

THE attention of many of the most able scientific men has been directed to the necessity for, and the means of obtaining, pure air. In our day the researches and experiments of Dr. R. Angus Smith (detailed in his great work entitled "*Air and Rain*") place him in the foremost rank of those who have studied the subject; in this country Professors Huxley and Tyndal, Dr. Parkes, Captain Douglas Galton, and numerous others, have rendered good service, besides a host of foreign scientists.

The subject can no longer be neglected by the people generally—all require pure air to breathe, and the means of obtaining it in the artifical life which most people live is a subject of vital importance Few people realise what is meant by a sufficiency or deficiency of pure air. We purpose, at the outset, to give some facts, first, with regard to the amount each person requires, and, secondly, on the purity and impurity of air.

Professor Huxley, one of our first-living authorities in Physiological Science, says: "If an adult man, breathing calmly in the sitting position, be watched, the respiratory act will be observed to be repeated thirteen to fifteen times every minute. Each act consists of certain components which succeed one another in a regular rhythmical

order. First the breath is drawn in, or inspired; immediately afterwards it is driven out, or expired; and these successive acts of inspiration are followed by a brief pause. Thus, just as in the rhythm of the heart—the auricular systole, the ventricular systole, and then a pause, follow in regular order; so in the chest—the inspiration, the expiration, and then a pause, succeed one another. At each inspiration of an adult well-grown man about thirty cubic inches of air are inspired; and at each expiration the same, or a slightly smaller volume (allowing for the increase of temperature of the air so expired) is given out of the body.

"The expired air differs from the air inspired in the following particulars.

"Whatever the temperature of the external air is, that expired is nearly as hot as the blood, or has a temperature between 98° and 100°.

"However dry the external air may be, that expired is quite, or nearly, saturated with watery vapour. Though ordinary air contains nearly 2,100 parts of oxygen, and 7,900 of nitrogen, with not more than 3 parts of carbonic acid, in 10,000 parts, expired air contains about 470 parts of carbonic acid, and only between 1,500 and 1,600 parts of oxygen, while the quantity of nitrogen suffers little or no change. Speaking roughly, air which has been breathed once has gained five per cent. of carbonic air, and lost five per cent. of oxygen.

"The expired air contains, in addition, a greater or less quantity of animal matter of a highly decomposable character.

"Very close analysis of the expired air shows, firstly, that the quantity of oxygen which disappears is always

slightly in excess of the quantity of carbonic acid supplied; and, secondly, that the nitrogen is variable — the expired nitrogen being sometimes in excess of, sometimes slightly less than, that inspired, and sometimes remaining stationary.

"From three hundred and fifty to four hundred cubic feet of air are thus passed through the lungs of an adult man taking little or no exercise, in the course of twenty-four hours; and are charged with carbonic acid, and deprived of oxygen, to the extent of nearly five per cent. This amounts to about eighteen cubic feet of the one gas taken in and of the other given out. Thus, if a man be shut up in a close room, having the form of a cube seven feet in the side, every particle of air in that room will have passed through his lungs in twenty-four hours, and a fourth of the oxygen it contained will be replaced by carbonic acid.

"The quantity of carbon eliminated in the twenty-four hours is pretty nearly represented by a piece of pure charcoal weighing about eight ounces.

"The quantity of water given off from the lungs in the twenty-four hours varies very much, but may be taken, on the average, as rather less than half a pint, or about nine ounces. It may fall below this amount, or increase to double or treble the quantity."

Seeing the great part which air has to play in the purification of the blood and other vitalising processes, the importance that the medium itself should be as pure as possible is self evident.

In cities, towns, camps, and wherever human beings or animals live in large numbers, within limited space, in

addition to respiration, there are many causes of vitiation of air — the gases formed from the combustion necessary for heat and light, and from decaying vegetable and animal matter, as well as the dust and refuse incidental to town life, are all sources of contamination.

Air is composed of two gases, oxygen (which is the element supporting vitality and combustion), and nitrogen, which acts as a diluent of the oxygen.

These are mechanically mixed, not chemically combined.

Dr. Angus Smith, in his work, before-named, "*Air and Rain*," says, "My object is to show that there are impurities in our atmosphere which may be discovered by chemical analysis, and that the senses and general impressions are not at fault when they speak of the peculiarities of a town atmosphere. I had shown in a former paper that it was not a mere fancy to suppose that the air of crowded rooms was tainted, and that it contained a substance capable of nourishing organic forms, and therefore in itself organic; and although by no means an original idea, as may be shown from old writers, I consider it of importance that these things should not rest merely on ordinary observations, but should be more and more brought under the domain of careful experiment.

"It has often been said that we were unable to tell the difference betwixt good air of the fincst mountain side, and the worst of the Hospitals (by chemical experiment), or rather, we should now say, of the infected dens of large towns, so well described in various forms of late years to the public. It seemed to many as if the eye had obtained a mysterious power of seeing what was scarcely capable of being proved to be within the domain of substance, and the

smell had a power of observing what was more an influence than a positive thing!

"We live in air, and the air flows continually into our blood; no wonder, then, that we are influenced by climate, which means the condition of the air. When we speak of climate we think of the atmosphere in constant motion, bringing with it different degrees of temperature and moisture from distant regions. It is everywhere constantly changing, but the changes are more frequent and of greater amplitude in some places than in others. The average condition is the climate of a place. The changes made by the movements of the air are numerous. The operations of man also are productive of changes so striking and so vital, that we may be said to make a climate for ourselves, according to our mode of living. We rush over the world, scarcely considering that the air we inhale must change at almost every step; and we build our houses, not thinking that every field has a climate of its own, unless circumstances are more nearly the same than we can hope for in our own country. In extensive tracts, where soil, level, and inclination are similar, such as great prairies or steppes, there will be few changes until the borders are approached, in which cases, contiguity of other surfaces will produce a variation. In England, which is comparatively a small country, with much variety of soil, it is difficult to find a place where a short distance does not produce some change; and in Scotland, a still smaller and more varied country, the differences of climate are still more striking. Indeed, every farmer studies his land in this respect; and the fields are devoted to various purposes, according to climate as well as soil.

"We are compelled, daily, to consider the relation of the size of our rooms to the number of those within them, if we are to live in health ; those who neglect this suffer severely. Our towns have, to a great extent, been built without recognition of the great fact, and we suffer, as a nation, by acts that we know to be irrational, as in private.

"We are exposed to great changes of climate arising from the conditions of our civilization ; and although we cannot effect complete alterations, it is possible to do something. To learn the method, we must, by careful observation, ascertain how we are affected.

"Who would have thought that persons living in a swampy district could be cured of ague, and regain their steadiness of muscle, by simply putting drain pipes under the soil around them ? Who would have thought that cold, bracing weather, which is popularly supposed to be healthy, would be so deadly to many, as is shown by the Registrar-General's reports ? But so it is, and we despise less than before the instinct that shrinks from cold. Who would not be surprised at the meteorologist watching the fluctuations of his barometer, remarking, "this is a dreadful night somewhere, and wrecks must even now be taking place" ! But the admitted correctness of such inferences, and their practical utility, show the value of observations of the barometer, thermometer, and hygrometer, and of the wind and rain fall.

"It was with the desire of clearing the mystery of air to some extent, that I have devoted so much of my time to the subject ; and now I feel that whilst I have succeeded in doing much of that which I intended to do, I have not got beyond the limits which earlier observers attained by the

mere fineness of unaided sense, and by sound reasoning without experiment. Still, I hope, I shall be found to have put their suspicions into plainer language, proved that which they only imagined, and given in detail that which they only in a general, and we may add, in a vague manner, had attained.

"It is not my intention to give much historical matter. The history of our knowledge of air would make of itself a volume, and it might be a very interesting one, and almost amusing. It must stand by itself. It will be enough here if I give conclusions arrived at by my own experiments, as a rule, making occasionally very slight deviations in order to bring in the opinions of others when they seem necessary for the elucidation of the subjects.

"Circumstances led me to approach the subject, chiefly from a chemical point of view, with the occasional use of the microscope, because the condition of our knowledge at the time when I began the study, pointed distinctly to the use of chemical experiment, and the microscope as the means of advance.

"When the great discovery was made that oxygen was a part of the air, and was that which was required for breathing, men imagined the secret of health to be attained. Wholesome air was held as that which contained much oxygen, or vital air. Many experiments destroyed this hope of happiness to man; he found that no air of nature did contain more than 21 per cent. of oxygen, or at most only a slight trace above this, and that none contained much less, and that if it did contain more, its virtue was limited, since even oxygen was no panacea. Infection might exist if even there was a full amount of oxygen, and that

it might be absent where the quantity was below the average, this state of things occurring in many situations when artificial conditions interfered, such as want of ventilation, and also in natural conditions, where gases are formed, which required to be removed by currents. As an example of this, we have the gases from the dying vegetation, and the endless amount formed over much of the earth, and in the sea itself, by the destruction of life and incessant activity necessary on water and land, to remove the refuse and to make the way smooth for the living.

"Many persons have examined the air, and it will be seen that many results have been attained; but latterly these results have been very much alike, and it may be supposed that the question might be allowed to rest. The rougher work was done, and done well, but Regnault began to refine it. He first showed the fine distinctions in the amount of oxygen in pure and tainted air. My work has been, so far as the gases are concerned, to carry this out further and to give minute details. These show that the mountains and great plains have an atmosphere different from that of cities; everybody knew this, but there is shown also the amount of difference. It is true that in figures this appears small; but what is the meaning of small? If we measure size by per centage, it will appear small, but still smaller will appear the strychnine that destroys us, if we estimate the amount as a per centage of the weight of our bodies.

"The details will be given, but the general result of many analyses will be seen in the following tables. Under the head, constitution of the atmosphere, will include the experiments of others. Here follows an abridgement of the results obtained:

OXYGEN IN THE AIR.

(Per cent, or, if read as whole numbers, per million.)

	Volume Per cent.
N. E. Sea shore and open heath (Scotland) ...	20·9990
Tops of Hills (Scotland)	20·9800
In a suburb of Manchester in wet weather ...	20·9800
Do. do. do.	20·9600
St. John's, Antigua	20·9500
In the outer circle of Manchester, not raining	20·9470
Lower parts of Perth	20·9350
Swampy places, favourable weather, France and Switzerland .... 20·9220 to	20·9500
In fog and frost in Manchester	20·9100
London, open places, summer	20·9500
In a sitting-room, which felt close, but not excessively so	20·8900
In a small room, with petroleum lamp	20·8400
Do. after six hours.................	20·8300
Pit of Theatre, 11-30 p.m................	20·7400
Gallery of Theatre, 10-30 p.m.	20·8600
About back of Houses and Closets	20·7000
In large cavities, in metalliferous mines, average of many......................................	20·7700
In currents	20·6500
Under shafts in metalliferous mines, average of many	20·4240
Court of Queen's Bench, February 2nd, 1866	20·6500
In pumps or pits in a mine	20·1400
When candles go out	18·5000
The worst specimen yet examined in a mine	18·2700
Very difficult to remain in many minutes......	17·2000

" Here it is seen that all the atmosphere in open places has a similar amount of oxygen, and the differences take place in the second decimal place. Still there are differences ; suppose that instead of calling the last four numbers deci-

mals, we head them as whole numbers, we shall have 209,990 in a million, and so on.

"This table proves distinctly the diminution of oxygen in places where the air is breathed, and it proves also that the analysis of air by estimating the oxygen is an important addition to a knowledge of its purity. The exaggerated amounts of oxygen, at one time imagined, are not found, but the necessity for attending to small differences is abundantly proved.

"Carbonic acid exists in very small quantities in the atmosphere, but it increases around animals, and according to circumstances increases or diminishes around plants. The following is a summary, the particulars being elsewhere given:

CARBONIC ACID IN AIR.

(Per cent, or, if read as whole numbers, per million.)

	Volume Per cent.
In mines, largest amount found in Cornwall ...	2·5000
Average of 39 analyses............................	·7850
In Theatres, worst parts, as much as	·3200
In Workshops, down to	·3000
About Middens..............	·0774
During fogs in Manchester	·0679
Manchester Streets, ordinary weather	.0403
Where fields begin	·0369
On the Thames, at London.......................	·0343
In the London Parks and open places	·0301
In the streets..	·0380
On hills in Scotland, from 1,000 to 4,406 ft. high	·0332
At the bottom of the same hills	·0341
Hills below 1,000 feet	·0337
Hills between 1,000 and 2,000 feet...............	·0334
Hills between 2,000 and 3,000 feet...............	·0332
Hills above 3,000 feet	·0336

"It would be interesting to know what is the constitution of the air in various seasons of the year, and over various lands and crops, as well as amongst the crops, and in forests.

"It will be observed from the table, that the amount of carbonic acid does not fall below 0·03°; smaller values have, however, been observed in plains. When the oxygen rises high, the amount may be considered correct, even when the per centage is volumetrically wrong. For example, let some of it be as ozone; the condensation of the ozone would produce a result greater than 100°. The amount of nitrogen is generally calculated from the remainder, and not directly estimated. It may turn out that, by following this clue, we may obtain a mode of analysis of the air for ozone, if it is condensed oxygen.

"Some people will probably enquire why we should give so much attention to such minute quantities—between 20·980 and 20·999—thinking these small differences can in no way affect us. A little more or less oxygen might not affect us; but, supposing its place occupied by hurtful matter, we must not look on the amount as too small. Subtracting 0·980 from 0·999 we have a difference of 190 in a million. In a gallon of water there are 70,000 grains; let us put into it an impurity, at the rate of 190 in 1,000,000, it amounts to 13·3 grains in a gallon, or 0·19 grammes in a litre. This amount would be considered enormous if it consisted of putrefying matter, or any organic matter usually found in waters. But we drink only a comparatively small quantity of water, and the whole 13 grains would not be swallowed in a day, whereas we take into our lungs 1,000 to 2,000 gallons of air daily. The detection of impurities

in the air is therefore of the utmost importance, and it is only by the finest methods that they can be ascertained in small quantities of air, even when present in such quantity as to prove deleterious to health.

"We must remember also that the blood receives the air and such impurities as are not filtered in its passage, whilst it is the stomach which receives the water we drink, and that organ has for many substances a power of disinfection and destruction which blood does not possess. If, by inhalation, we took up 13 grains of unwholesome matter per day—half a grain per hour—we need not be surprised if it hurt us. Such an amount is an awful dose of some poisons, and yet, this is not above one-thousandth part of a grain at every inhalation. It is marvellous what small amounts may affect us, even when, by repeated action, they do not cumulate as poisons do. The carbonic acid numbers might have been used instead of the oxygen numbers, with the same result. On the actual effect of carbonic acid there are separate experiments; but its amount, as given, is an important index to the state of the air. The organic matter is the dangerous agent, but not all organic matter; some probably may be wholesome, some neutral, and some putrid, but the most dangerous seems to be the organised, existing as minute germs, and perhaps as full grown plants or animals also.

"We began by assuming very small shades of difference, namely, 190 in a million; but if we examine the table we find much greater amounts. Take, for example, the pit of a theatre; we have by subtracting 20·74 from 20·999 a difference of 2,590 in a million, or 14 times more. And so on we may go to the lowest, where we may have 17·2, which

taken from 20·999, leaves 3·799, or 37,990 in a million, or 200 times more than the first example. The conclusion to be drawn from all this simply is, that we cannot make the analysis too minutely, and that every deviation from the standard of purity is to be observed and considered."

Ventilation, *i.e.*, the supply of a sufficient quantity of fresh air, and the removal of that vitiated, is therefore a matter of the first consequence to health, and ought certainly, to be the first object considered in the designing of any building intended for human occupation.

So far, however, are we from having any recognised system of ventilation, that many large buildings are even now erected without the slightest provision for either the admission of fresh air, or the removal of that vitiated. Even when it is determined to give due attention to ventilation, the study of the subject is beset with difficulties. Authorities are contradictory, and much research and judgment are required to produce a satisfactory scheme. This having been the experience of the author and his friends, in several large buildings about which he has been consulted, he has thought it would be an advantage to gather into one volume accessible facts connected with the subject.

Among the many who have devoted attention to ventilation, few have taken the trouble to work out any complete system. There has been too much speculation and theory; and most of our so-called authorities are "specialists," who have taken up some particular cowl or valve, and are anxious to publish its virtues.

In the middle ages populations were not so dense, and people lived mostly out of doors; when they did congregate under cover, it was in comparatively small numbers, and

for short periods. Churches and Cathedrals, where alone any considerable number could be collected, were very lofty, and thus until, modern times, a system of ventilation was not a pressing necessity.

In our day, however, crowded assemblies with artificial light are frequent, and for the thousands who spend hours together, under circumstances of excitement, a good and constant supply of fresh air is of the first importance, and can only be insured by a system of ventilation, arranged for when a building is in course of erection. When artificial ventilation was found necessary, the first idea was to form openings in any situation in the walls to admit the supply of air, and also some outlet for the escape of vitiated air.

Sir Humphrey Davy, who was one of the first men of science to consider this subject, was consulted about the ventilation of the Houses of Parliament, in 1811. In the House of Commons, he provided an outlet for vitiated air, one foot square; in 1813 this was increased to three feet; a few years later Dr. Reed increased it to fifty feet!

It was at this period that ventilation and warming, for the first time, received a due share of attention, and this may be considered as the first attempt, in this country, to place the subject on a scientific basis. In the temporary House of Commons (occupied during the erection of the permanent building) numerous experiments were tried, until it was considered that perfection was reached. To quote the words of one of the engineers engaged, "the air supplied was sifted, washed, partly warmed, mixed, and tempered, and admitted to the House in a gentle and uniformly diffused stream. It could be supplied in almost any

desired volume, and at almost any desired temperature, within reasonable limits, and suited to a house composed of thirty or five hundred members."

Dr. Reed has given to the world the benefit of these experiments, and their results in his work, entitled "*Theory and Practice of Ventilation*," and this may be considered the first book published in this country, with any pretensions to scientific accuracy on the subject.

It will scarcely be credited that, notwithstanding these elaborate experiments, the arrangements for the ventilation and warming of the present Houses of Parliament were not carried out on any plans, but seem to have been "thumbed out." In a report on the ventilation, warming, and lighting of the Houses of Parliament, issued March 7th, 1866, Dr. Percy says:

Want of Plans.

"It is remarkable that there are no trustworthy plans of the arrangements for warming and ventilating the Houses of Parliament. There are many hundreds of air-courses under as well as aboveground, beneath floors, in walls, over ceilings, and in roofs; some for supplying cold air, others for supplying warm air, and others again for carrying off vitiated air; there are air-valves in every part of the building; there are enormous smoke-flues running horizontally within and immediately under the roofs, with hundreds of chimneys in communication; there are, it is asserted, steam-pipes of which the aggregate length is 15 miles, and about 1,200 stopcocks and valves connected with these pipes; and there is a multitude of holes and crannies as intricate and tortuous as the windings of a rabbit warren. It is not possible that any man should accurately remember these details,

even if he had seen every stone and brick laid; and in the absence of plans occasional blundering will be inevitable. It is satisfactory to state that no sooner was the First Commissioner made acquainted with this urgent want than steps were taken to supply it, and an architectural draughtsman has been engaged for the purpose of preparing the necessary drawings. For several months this gentleman and two of the most experienced men of the staff have been occupied in the work of exploration, which has proved to be laborious as well as difficult; and in many cases it has not been possible to trace accurately the course of the the air-passages. All the air-courses in the Speaker's house, in the west front, and in the river front, above the basement, have thus been explored, described, and catalogued; and plans of them are in progress. A considerable time must elapse before this investigation will be thoroughly completed. Much has been discovered not previously known to any person in this department, and not a few erroneous notions have been corrected. Duplicate descriptions will be deposited at the Office of Works in order that they may be securely preserved for future guidance. It is almost needless to remark that without accurate plans this department is entirely at the mercy of the persons now engaged, and that even supposing any one or several of these persons possessed a complete knowledge of all the arrangements for ventilation, which is not the fact, it would not be safe to trust to their memory alone."

No doubt a duplicate set of plans will now be at the office of the First Commissioner of Works, but hitherto they have not been published, and are not available to the public.

If they were, they would not be of any great service as a

guide for other large buildings; the system adopted is very complicated and expensive, and it is to be regretted that so much public money was spent, and that the nation generally derives so little benefit from it.

Prisons.

About the same time that the experiments were being made at the temporary Houses of Parliament, the Government determined upon the erection of the Pentonville Model Prison, and the construction of it was entrusted to Major J. Jebb, Surveyor General of Prisons. He carried out his plans with great skill, and his system is a success in every particular; the ventilation and warming was a great advance upon anything that had been done up to that date, and was a substantial contribution to science, and it may be said inaugurated a new era in scientific ventilation. It is a curious fact that the system of warming and ventilating at Pentonville has made greater progress on the continent than in England, and is mostly known, even by Englishmen, not as Major Jebb's but as General Morin's system, and he, a Frenchman, has done more than any Englishman to elaborate and make it known, and has applied it in various forms. He has adopted the system in many large buildings in France, and has illustrated it in his great work, which comprises two large volumes, "*Études sur la Ventilation.*" In that work he gives the result of numerous experiments, and some minute calculations, which must be valuable to engineering students.

As Pentonville Prison forms a sort of landmark in warming and ventilating engineering, some illustrations are here included, giving a general idea of the system. It will be

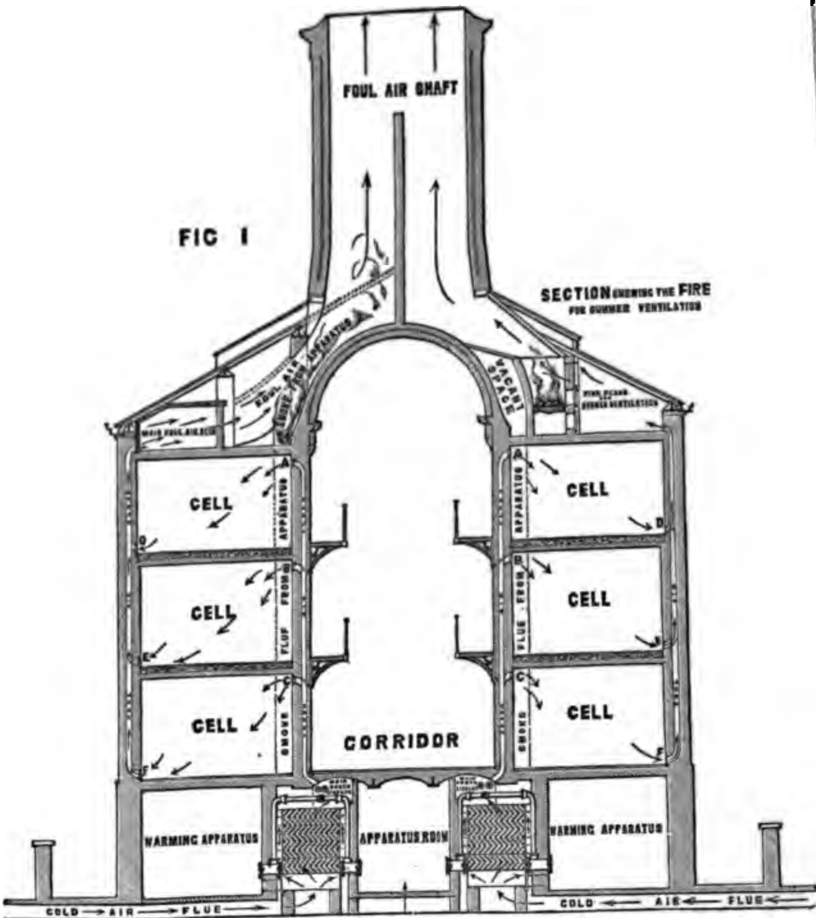


Fig. 1.—SECTION OF PENTONVILLE PRISON.

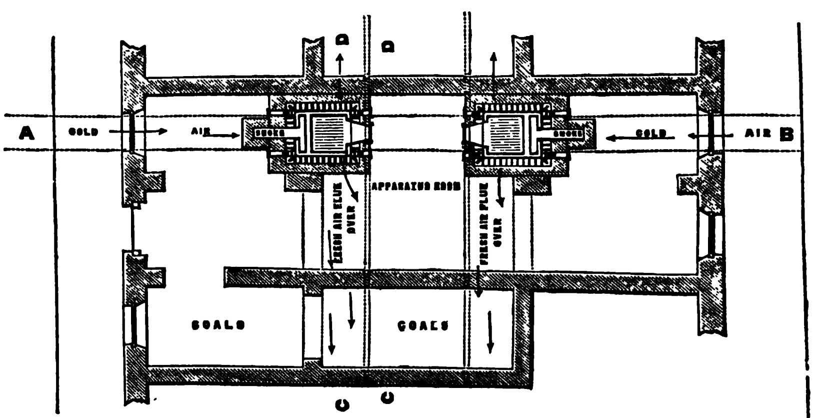


Fig. 2.—PLAN OF APPARATUS ROOM.

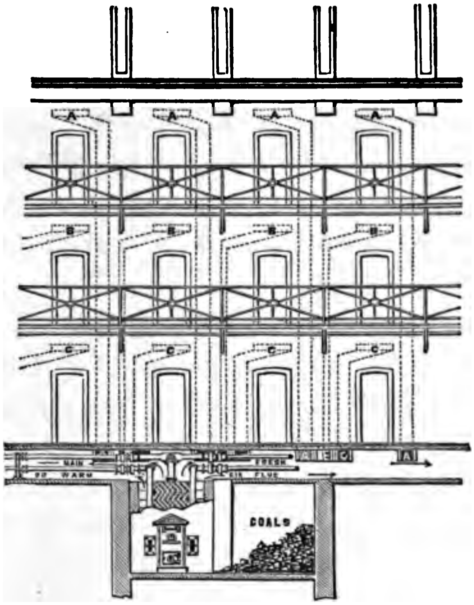


Fig. 3.—Section of Portion of Pentonville Prison.

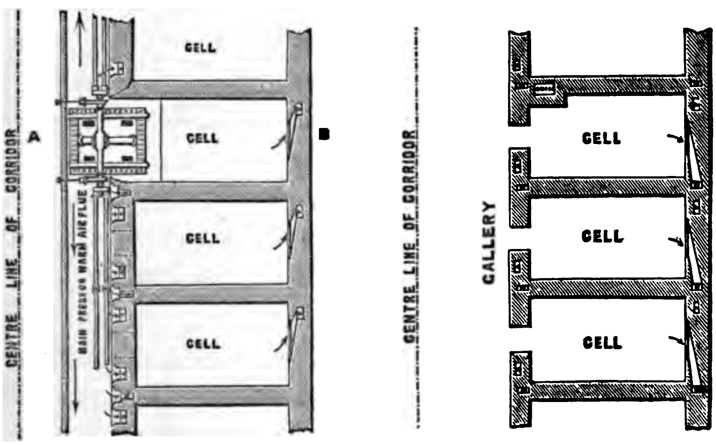


Fig. 4.—Plan of Cells, &c.

seen that no mechanical means are used, and that none are necessary to force the air into the various cells. The boilers

and coils of pipes, which are so numerous, are in a chamber in the basement, from which the warm air shafts ascend, and the small flues convey the air to each cell from the main shaft, and a separate set of flues convey the vitiated air to one main shaft, where a fire can be lighted (*if need be*) in the upper part, to keep up the current, and the supply of cold air is drawn from the outside of the building to the chamber where it is warmed.

Architects and others who are interested in the construction of prisons, will find all particulars in Major Jebb's Government report on the construction, ventilation, and details of Pentonville Prison, 1844.

The reason why Major Jebb's system has not been more generally used, is in consequence of the first cost, which is enormous. The Glasgow University, which was erected in 1865, it may be mentioned, was warmed and ventilated on this system. The total content is 2,035,000 cubic feet of space, and the cost of warming and ventilating was £17,000, and cost of maintainence £500 per annum, setting something aside for occasional repairs. The consumption of fuel, 2 tons 3 cwt. per day.

The amount thus expended at the Glasgow University may be taken as a fair specimen of the cost to carry out this system. Notwithstanding the great cost, Professor James Thompson says of it:

"The arrangements carried out for warming and ventilating in Glasgow University, were to be regarded as only in a moderate degree successful. They were far from admitting of being contemplated with satisfaction, and this for various reasons. In the class rooms of several of the large classes the scheme turned out to be quite inadequate as to ventila-

tion. In some of them, which were crowded with students, after strong complaints of the oppressiveness of the air, it had become necessary to have recourse to the opening of windows in winter weather, to mitigate the evil. But the opening of the windows completely subverted the intended ventilation arrangement, and rendered them in the main nugatory. Such results, he said, inevitably must be entailed by the abandonment, in the executed scheme, of the originally intended essential arrangement, that besides the hot fresh air, cold fresh air should be supplied to each class room, with means for mixing it. The abandonment of this provision was a mistake fatal to the scheme; and if the adoption of the provision would have proved too difficult, it would have been better to drop the scheme as a whole, and to have entered on designs for the undertaking in some other way altogether. To ventilate a crowded class room, new air must be supplied, amounting in volume to many times the contents of the class room per hour.

"But if this air for ventilation is supplied hot from a system of conduits suitable for warming other class rooms, before the meeting of the students, or class rooms with only a few occupants, the temperature in the crowded class rooms must necessarily become intolerably high. The bodies of the occupants, with their breathing included, would make the room very hot, and would render the air badly vitiated, unless a large flow of new air were maintained passing through the room, in such a way as to scour off the vitiated air from around them. Now, obviously the air to be supplied for a crowded meeting must enter in large quantity, and at no higher temperature than that of air desirable for surrounding the occupants, and for being breathed by them,

But the air in the ducts which lead to some of the crowded rooms, is, he said, ordinarily at about from 90° to 109° Fahrenheit, and some such temperature is requisite to provide sufficient warming in other rooms. In several of the class rooms the hot ventilation air comes in by openings, about half way up the walls, and goes away in great part by passing clear over the heads of the occupants to wall head outlets, without ever coming down for the use of the occupants, the cooler air tending to stagnate around them in the lower half of the room."

The engineer made a great mistake in not providing means for an ample supply of fresh air for all the class rooms, but especially those to be occupied by a large number of students. This could have been easily and effectually accomplished at little cost, and as the building is formed in wings, it could yet be done—and without in any way disfiguring the rooms—by means of inlets on the so-called "Tobin" principle.

Infirmaries and Hospitals.

The object of the erection of a hospital being the placing the patient under the most favourable conditions for recovery, all hygienic appliances are of the greatest possible importance. Light, air and warmth are most essential. Efficient ventilation only can dissipate and carry off the effluvia of disease, and prevent those diseases peculiar to badly constructed hospitals. To commence with, the best authorities are agreed that the minimum of air space for each patient should be 1,000 cubic feet, and that the air should be changed at the rate of at least 20 cubic feet per minute per patient.

dern form of construction known as the pavilion
nsisting of blocks or pavilions of wards isolated
cted by open corridors, has for its chief recom-
s the advantages of thorough natural ventilation.
are kept sufficiently narrow, and the windows on
being opposite each other, from floor to ceiling,
complete sweeping out of stagnant air as often as
Of course it is not always practicable to have win-
to the extent named, and it is therefore desirable
e windows constructed in three or more divisions,
ome
di-
may
e o-
ex-
me-
that
in
oard
of di-
the
into
three; the
bottom por-
tion being the
ordinary slid-
ing sash, hung
as usual, and
the top por-
tion a sheet
falling in-

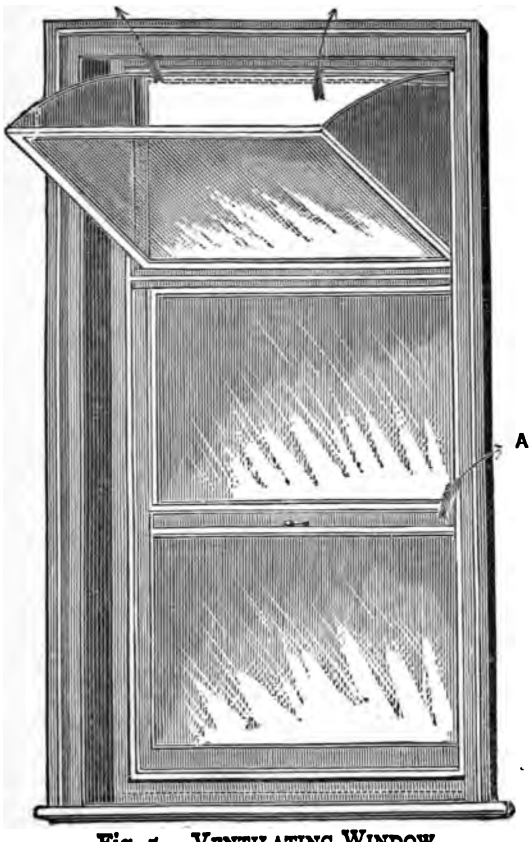


Fig. 5.—Ventilating Window.

But the air in the ducts which lead to some of the crowded rooms, is, he said, ordinarily at about from 90° to 109° Fahrenheit, and some such temperature is requisite to provide sufficient warming in other rooms. In several of the class rooms the hot ventilation air comes in by openings, about half way up the walls, and goes away in great part by passing clear over the heads of the occupants to wall head outlets, without ever coming down for the use of the occupants, the cooler air tending to stagnate around them in the lower half of the room."

The engineer made a great mistake in not providing means for an ample supply of fresh air for all the class rooms, but especially those to be occupied by a large number of students. This could have been easily and effectually accomplished at little cost, and as the building is formed in wings, it could yet be done—and without in any way disfiguring the rooms—by means of inlets on the so-called "Tobin" principle.

Infirmaries and Hospitals.

The object of the erection of a hospital being the placing the patient under the most favourable conditions for recovery, all hygienic appliances are of the greatest possible importance. Light, air and warmth are most essential. Efficient ventilation only can dissipate and carry off the effluvia of disease, and prevent those diseases peculiar to badly constructed hospitals. To commence with, the best authorities are agreed that the minimum of air space for each patient should be 1,000 cubic feet, and that the air should be changed at the rate of at least 20 cubic feet per minute per patient.

The modern form of construction known as the pavilion system, consisting of blocks or pavilions of wards isolated and connected by open corridors, has for its chief recommendations the advantages of thorough natural ventilation. The wards are kept sufficiently narrow, and the windows on each side being opposite each other, from floor to ceiling, allow of a complete sweeping out of stagnant air as often as desired. Of course it is not always practicable to have windows open to the extent named, and it is therefore desirable to have the windows constructed in three or more divisions, so that some of the divisions may always be open. An ex-excellent method is that adopted in many Board Schools of dividing the windows into three; the bottom portion being the ordinary sliding sash, hung as usual, and the top portion a sheet falling in-

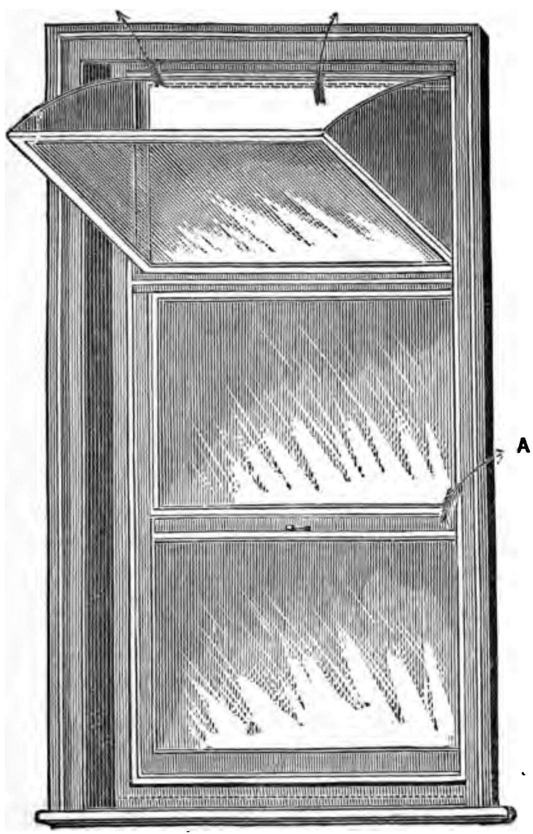


Fig. 5.—VENTILATING WINDOW.

wards, with wood or metal side pieces to throw the current upwards and prevent a direct draught. This latter could be almost always open.

In addition to this arrangement, it is advisable to make the bead on sill about 3in. deep, so that the bottom sash sheet may be lifted to that extent, and allow an upward current to pass in at the meeting bar A without any draught at the sill.

The Sherringham valve is also a most valuable adjunct, admitting an upward current direct from the outside. These can be placed in any corner, or where stagnation of air is feared. It is an advantage, also, to have an arrangement of grids under the beds communicating directly with the outside (but capable of being closed) so as to sweep away any air stagnating under the beds, when required.

In addition to these arrangements, provision must be made for an ample supply of warmed air to mix with the cold air admitted, and keep the whole ward at an equable agreeable temperature. When an open fire is a desideratum, the best arrangement is found in one of the various stoves, on the principle introduced by Captain Galton, where the heat radiated from the fire directly is supplemented by a chamber at the back and sides of the fire, through which a current of fresh air passes into the ward, and is warmed in transit. The most economical method, however, is to warm the air in a chamber in the basement with warm air flues to each ward. In towns the air can thus be filtered or washed on its way to the apparatus.

In warming Hospitals and Infirmaries, France is far ahead of us. We have no recognised system. In the military Hospitals of France, General Morin has developed, and

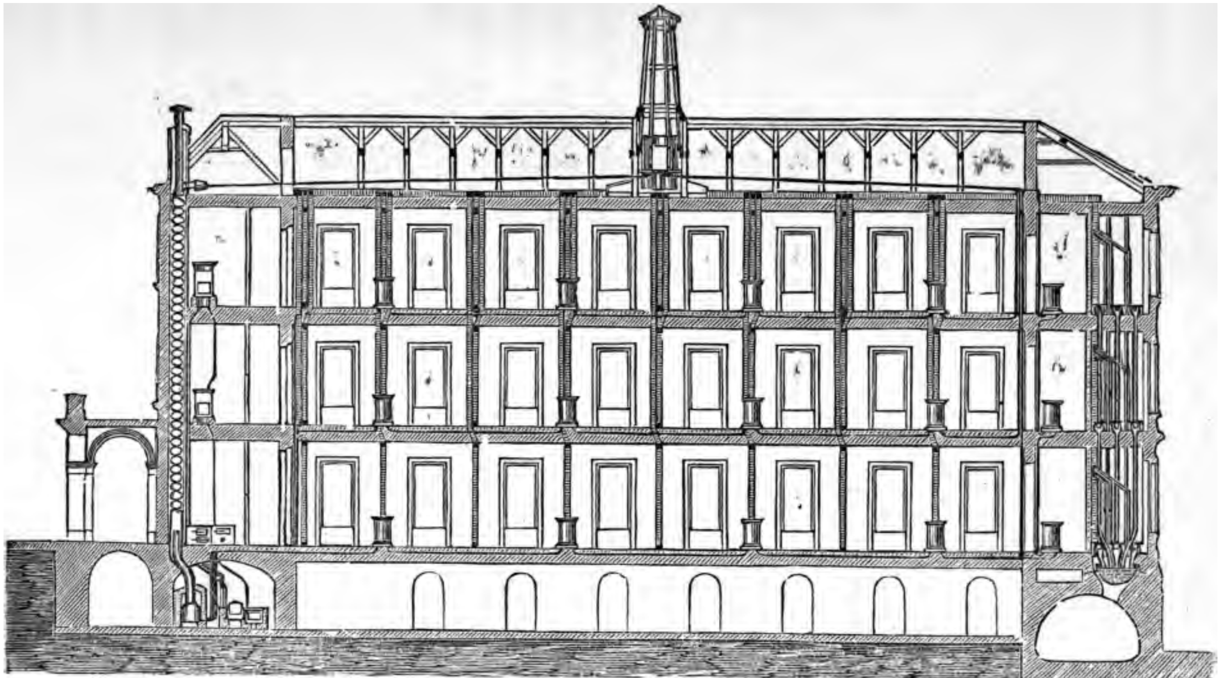


Fig. 6.—Section, Lariboisiére Hospital, Paris.

carried out, a system of warming which is effectual, but most expensive; the warming is effected by the circulation of hot water in pipes, and he fixes coils in the various wards and corridors, each coil encased, and the case supplied with a constant current of fresh air from the outside. The whole scheme is very much better than is usually adopted in this country, when the circulating system is used, that is, of running hot water pipes through the rooms, which simply warm the air that happens to be in the room. The engraving annexed gives a general idea of General Morin's system of warming and ventilation at the Lariboisiére Hospital, near Paris.

As shewn in the plate, a cistern in roof supplies a boiler in the basement, from which pipes are taken and formed into coils in the various apartments as before named. It may be noticed that an attempt has been made to economise heat by bringing the pipes in a serpentine form down the smoke flue. This, however, does not seem to be worth while, and might cause trouble with the smoke, or if repairs are needed.

Buildings for large Gatherings.

The prevailing notions as to the warming and ventilation of Churches, Chapels, Schools, Town Halls and Concert Rooms, indicate a state of mental chaos. The most primitive means, both of ventilation and warming, are still in use and are being applied to new buildings, and many large and important buildings are, even now, erected without any provision whatever for either warming or ventilation. For warming Churches and Chapels all varieties of heating apparatus are tried; even the Roman hypocaust is now

and again adopted, though in execution the work compares badly with that of the ancients. We have the common "Cockle," the first advance from the hypocaust, sometimes standing on the floor as a radiator, but more frequently fixed as an underground air warmer. In some cases the "Cockle" is let into the floor of the place to be warmed, and the smoke pipe traverses the whole length of the building, so as to economise all the heating power. In places of worship this is very objectionable, as the fuel and ashes cause much dirt.

The variation in the amount of tenders for the warming of large buildings is most curious. We give an instance which is a fair specimen of what we continually meet with. A new Church in Wales was to be warmed, and the following tenders were submitted: (it contained 16,854 cubic feet of air space). G £200, S £170, B £125, G £120, by water; S £85, C £80, G £60, P £30, hot air!!—This last was accepted!! After this as a sample, can we marvel at failures in warming?

It might seem that thorough ventilation and efficient warming of large buildings was a very difficult and doubtful matter, whereas it is neither. Formerly it was thought that an engine and fan were necessary to force sufficient air into large rooms, but with properly constructed flues nature's laws may be relied upon to do the work most effectually. The force generated by the difference of temperature in any building where people are assembled, from the temperature of the atmosphere outside, if judiciously directed, will always be sufficient to produce such a circulation and diffusion of fresh air as will answer all purposes of ventilation. As a matter of comfort, and to anticipate the rise of tem-

perature, as well as to warm the walls, roofs, &c., in the winter months, it is necessary to raise the air in the room to a genial temperature before the arrival of the people; but this warming should not be continued after the circulatory action has commenced. The method proposed as applicable to all public rooms may, perhaps, be best practically illustrated by a description of the system at the Free Trade Hall, Manchester, the grand hall of which, containing some 500,000 cubic feet of air space, and *seating* 4,000 people, is admitted to be one of the best ventilated rooms in this country, and considering its success, it has not been brought sufficiently before the public. The following description we contributed to the *Building News*, May 25th, 1877:

The Free Trade Hall, being intended for very large gatherings, it was of the utmost importance that the large room should be thoroughly well ventilated, and acoustically as perfect as possible. Before deciding on the plan, the late Mr. Walters visited many of the principal meeting-rooms in this country, in search of a model system of ventilation, but, finding nothing to satisfy him, he was thrown upon his own resources, and finally adopted the present arrangement, which so far has not been excelled in any public building. The hall having been erected 20 years ago, it would be marvellous indeed if nothing in it could not *now* be improved upon. The general arrangements for ventilation and warming being successful, the points where improvements might be suggested will be mentioned as they occur. As shown on plan,—under the basement floor a flue is formed in brickwork measuring 3ft. by 2ft. 2in., running round the walls, directly supplied with fresh air from the outside by three large openings. (In buildings where there is no basement,

or in any where there is sufficient room, it would be an improvement to form the whole of the space under the floor into an open chamber, always providing ample openings for access of air from the outside.) From this flue are carried up in the thickness of the wall, as shown, 18 vertical flues, each 2ft. by 1ft. 2in., delivering fresh air between the ornamantal pillars in the gallery, about 8ft. from the floor (see Section). (It will be seen that the so-called Tobin invention is here anticipated, the air being delivered vertically.) The inlet being sufficiently elevated above the heads of the people, no draughts are felt, and an ample quantity of fresh air can be introduced. (The absence of draughts is of great importance, as the advantages of the best system of ventilation may be neutralised if draughts are caused. It would be an improvement to open inlets from the vertical flues under the gallery as well as above, thus helping the more rapid diffusion of the fresh air throughout the hall.) The foul air is carried away by openings round the 15 sunlights in the ceiling into two flues, each measuring 4ft. 3in. by 3ft. 9in. inside, formed of lath and plaster, and running along the inside of roof as shown on plan, one each side of hall. These meet at the end furthest from the platform, and deliver their contents into an upright shaft 7ft. 9in. by 5ft. 7in. inside, surmounted by a cowl. The cowl, which works easily with the wind (always turning its mouth to leeward), has only the movable portion exposed above the roof, and is situated just on the apex of the hip, as shown. (Here it may be remarked that the outlets into flues over the sunlights are contracted, and the cowl has only about the sectional area of one of the foul air flues. It would render the ventilation almost perfect if, say, two

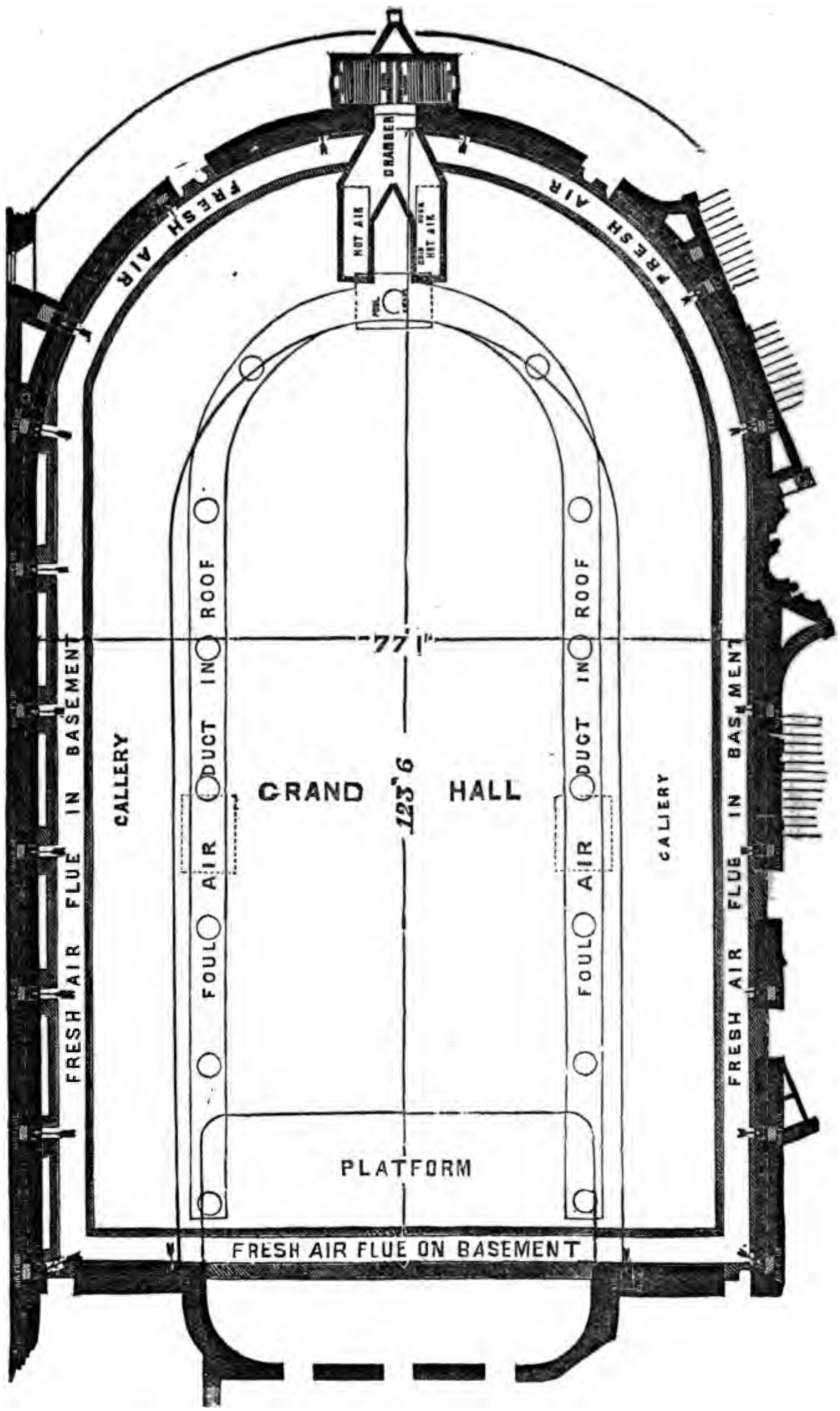


Fig. 7.—PLAN OF FREE TRADE HALL.

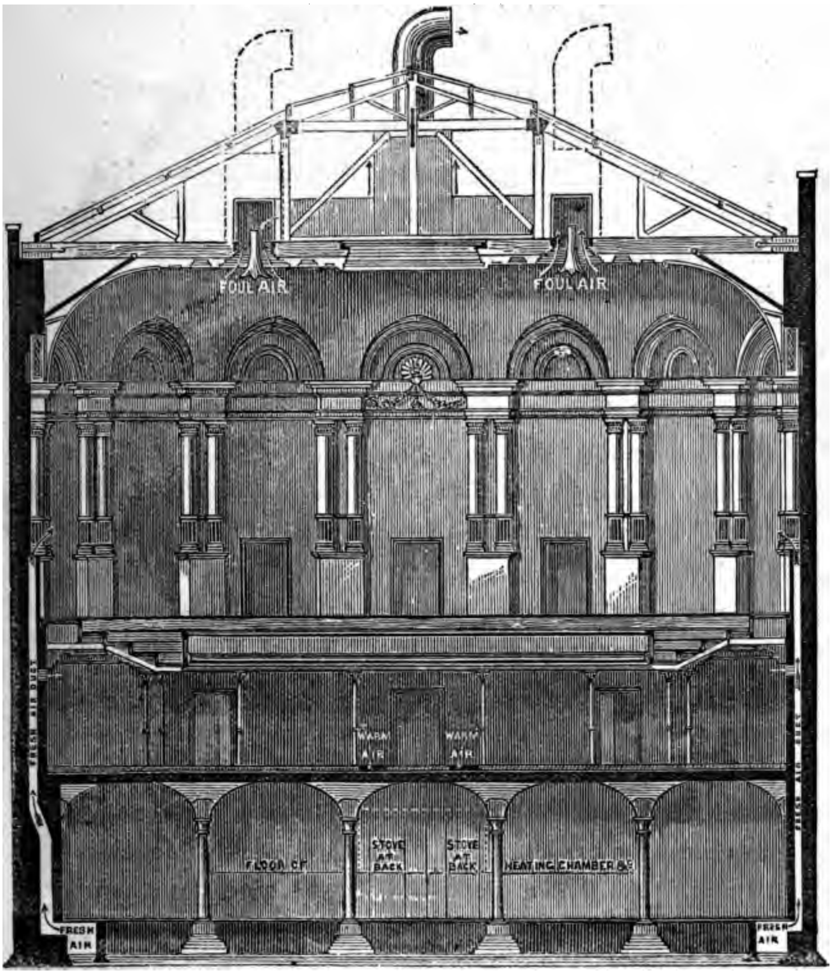


Fig. 8.—SECTION OF FREE TRADE HALL.

more cowls of about the same capacity were added, and would give the advantage of more immediate outlet to the vitiated air. It may safely be said, then, that the whole air of the room could be easily changed three times in the hour, which would be of the greatest advantage when the hall was crowded).

It ought to be stated that when the hall was opened the vitiated air, with its load of vapour, was admitted into the roof, the foul air flues not being formed. Their construction was an afterthought, and a matter of necessity, the condensation in the roof being so great that the ceiling would have been materially injured by the water thus produced. By means of the flue, the foul air is carried away as fast as it is delivered, and has no time for condensation.

On the occasion of a large and crowded concert recently, it was found that the outlet of air was 9,300 cubic feet per minute, and the amount of carbonic acid in the air leaving the flues, near the close of the concert, was 7,730 parts per million, the temperature in the foul air flue being from 180° to 208° Fahr. Of course a large amount of the heat registered was due to the gas burnt. The system of ventilation indicated can be readily adapted to most buildings now erected, without any great outlay. The air flues which we have named as being formed in the thickness of the walls may be constructed of terra-cotta, iron, or even lath and plaster as pillars or pilasters, and may, in skilful hands, be made to conduce to ornamental effect. There is, therefore, no excuse for any large public room being left without ventilation. As before mentioned, however satisfactory the arrangements for ventilating may be, an efficient heating apparatus is necessary in the winter season, to produce and maintain a genial and uniform temperature, and especially to warm the hall before the arrival of the people. Failures in effectual heating are as frequent as inefficient ventilation, usually from the inadequacy of the means employed. It could be hardly expected, for example, that the air of a room like the great hall of the Free Trade Hall, 52ft. high,

could be raised to a genial temperature, in a reasonable time, by means of hot water or steam pipes round the floor. This system, however, was tried, at a cost of some £700, but the directors being dissatisfied with the great outlay for repairs, &c., each season, were obliged to look round for something more efficient and durable. The difficulty was then to find any satisfactory air-warmer. As an experiment the Directors had two large Convoluted Stoves, costing £270, placed in the position shown on plan; the Great Hall is warmed before the people enter, and the result is, that, without any back draught, or any difficulty from outside temperature, force or direction of wind, &c., the room is thoroughly comfortable all the evening. The time occupied to produce a comfortable uniform temperature throughout the room is about four hours. The consumption of coke averages about 4½ tons, at a cost of about £2 10*s*., for the whole winter season.

The Manchester Royal Exchange,

Being one of the noblest buildings in Europe, the plan and section will be interesting to many readers. *The Builder,* October 29th, 1870, gave the following description:

"The Manchester Royal Exchange, of which we this week give illustrations, is now being erected under the direction of Messrs. Mills and Murgatroyd, architects. The building occupies a portion of the site of the Old Exchange, erected some twenty years since, together with a considerable additional plot on the east side thereof, the total area covered being 5,400 square yards. The land being, from

its central position, about the most valuable in Manchester, the proprietors were compelled to look to other sources of revenue besides their subscription list (now numbering upwards of 6,000 members) for a return upon their capital of £450,000; and as the irregularity of level of the surrounding streets (which will be considerably widened by portions absorbed from the site purchased) necessitated the floor of the Exchange-room being placed some distance above the level of the lowest point, it was determined to make that distance sufficient for obtaining shops below the room, and fronting to three of the streets.

"Behind the shops are spaces adapted for stores and a restaurant, and also a central hall, approached from Bank-street, in which carts can be loaded and unloaded in connexion with the two stories of fire-proof cellars reaching to a depth of 24ft. below the street level. The service to these cellars will be by means of hydraulic hoists. The ceiling of the shops, central hall, and stores, forming the floor of the main room, is fire-proof, consisting principally of rolled iron joists and concrete.

"The main entrance to the room is in Cross-street, and consists of an octostyle Corinthian portico, approached by a flight of steps on either side: the columns are 3ft. 6in. diameter, and 35ft. high; and the pediment will be filled with the Royal Arms removed from the Old Exchange, with its supporting figures, &c., and which was a work of the late John Thomas.

"The Corinthian order is carried out throughout the fronts of the building. Besides the principal entrance in Cross-street, formed by a fine granite-cased opening from the portico, there are other subsidiary entrances near the four

corners of the building; the one at the corner of Exchange-street and Market-street being surmounted by a tower, 180ft. high, forming a central feature at the end of Victoria-street, which approaches the side diagonally on the axis of the tower. The windows in the angle blocks or pavilions, containing the staircases, have arched heads, which will be filled with groups of sculpture, by Mr. E. G. Papworth, by whom also other figures and groups have been prepared for suitable places intended for their reception, all being illustrative of the industries of the principal towns of Lancashire and of the nationalities with whom her commerce is conducted.

"The plan will show the general arrangement. The whole area of the site at this level is, with one or two trifling exceptions, given up to the use of the subscribers, the area of the room itself, of which we shall give a view, being of the large extent of 4,050 superficial yards, as against 1,620 in the old building. This is exclusive of the reading-room (340 square yards), portico, &c.

"The room may be said to consist of a central nave, 96ft. between the walls, and side aisles beyond, extending to the outer walls of the building. The nave is surmounted by a large central hemispherical dome 62ft. in diameter, carried on pendentives, and by two smaller segmental domes, the height from the floor to the eye of the central dome being 120ft. The aisles are less in height than the nave, and above them are constructed ranges of offices, &c., approached by the staircases shown on the plan, and which will be let off, and will no doubt be found very convenient for merchants and others having business to transact on the Exchange. The architectural arrangement of the large

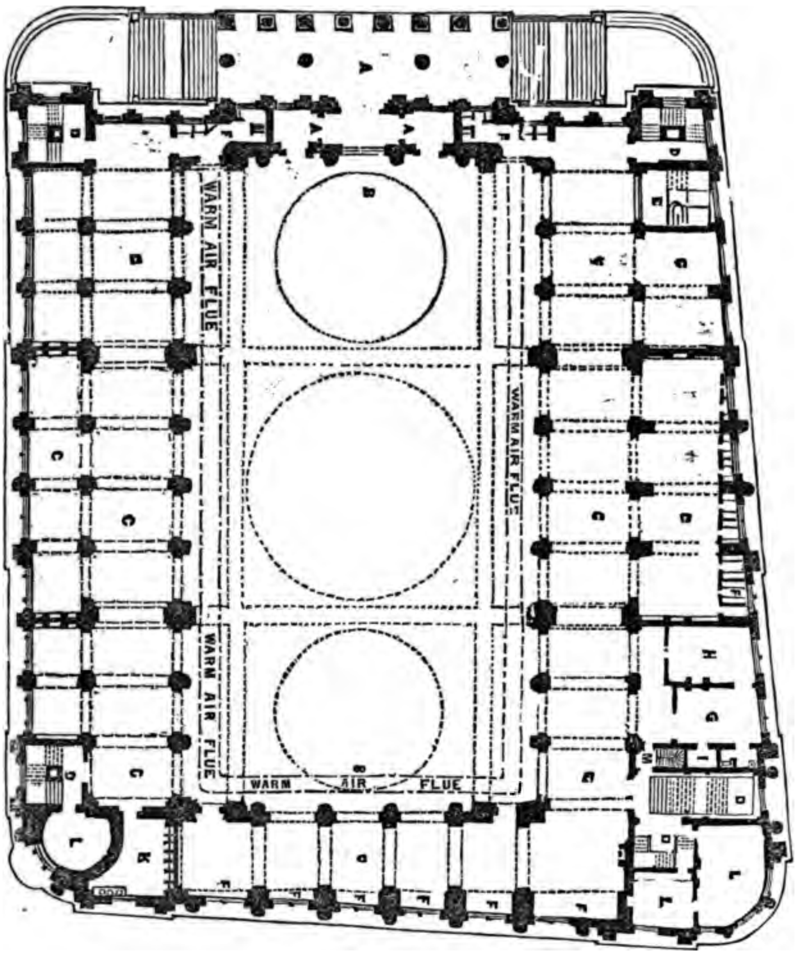


Fig. 9.—PLAN OF ROYAL EXCHANGE.

room consists of a range of arches springing from pier to pier, these being separated on the side next the nave by columns of Irish red marble, 3ft. 2in. diameter and 33ft. high, and standing on grey marble plinths, 5ft. high ; the large pilasters, also, are cased with red and grey marble, all

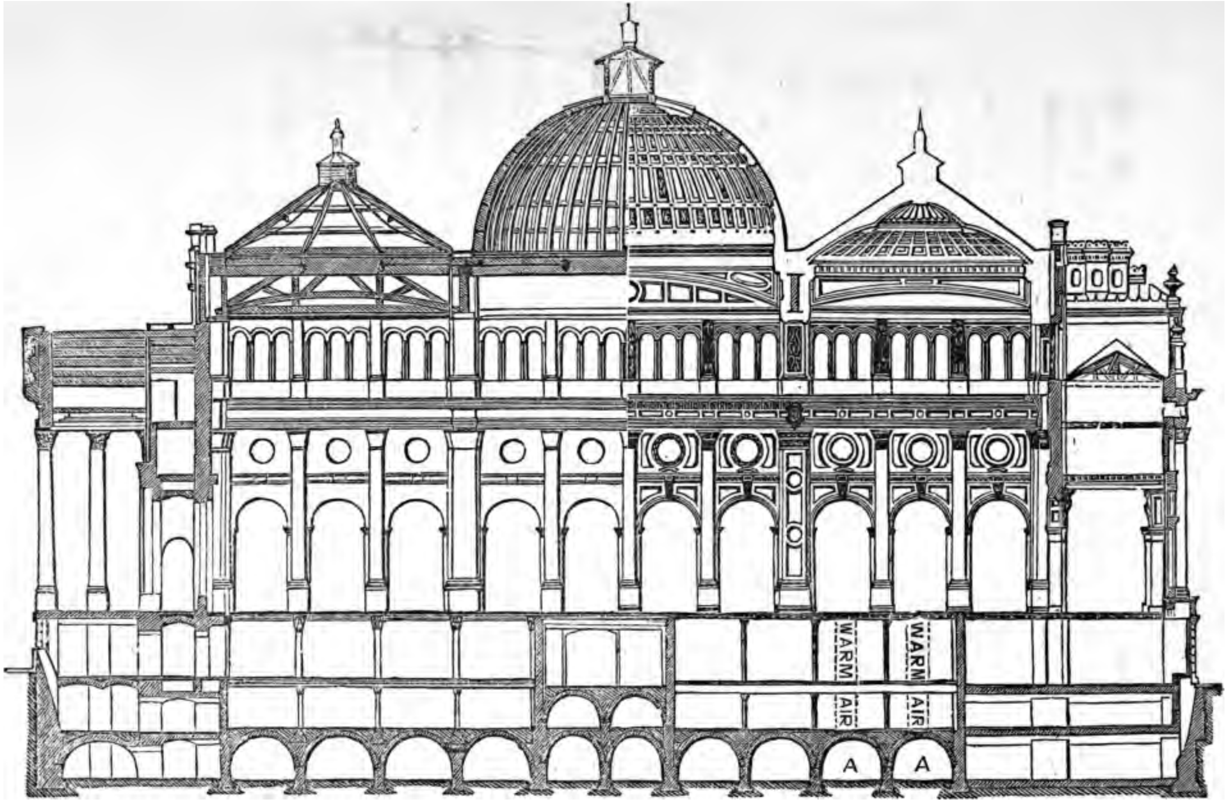


Fig. 10.—Section of Manchester Royal Exchange.

being from the quarries of Messrs. Sibthorpe & Son, of Dublin. Above the entablature is a clearstory, the shafts carrying the arches of which are of terra cotta, made by Messrs. March & Sons, of Berlin. All the lights of the clearstory will be made to open by machinery for ventilation, for further promoting which shafts are prepared, through which warm or cold air is intended to be driven into the room by a fan and steam-engine placed in the basement."

It will be seen from the foregoing description that warm air shafts were provided, and that a steam engine and fan was intended to be used to force the warm air from the basement to the large Hall. The successful warming of the Free Trade Hall by the Convoluted Stove led to its adoption at the Royal Exchange, and two powerful stoves are fixed in the basement. The warm air is conveyed to two flues which run the full length of the "nave" in front of the pillars, with a branch flue into the plinth of the columns from which the warm air is delivered.

The fresh air is drawn from the top of the building. A large shaft about 6ft. square was provided when the building was in course of erection, and at the bottom of this shaft, a large cold air chamber is fitted with filter cloths, which take the "smuts" out of the air.

The whole arrangement is simple and effective, and no engine or fan is required. The Grand Hall is easily warmed; the apparatus is fired during the night, the fires are banked up through the day, as a high temperature is not required. The following table shows the temperature between the dates named:

Register of Thermometer in the Royal Exchange and outside temperature.

1879.		In the Room.	Outside.	No. of Stoves worked.	1879.		In the Room.	Outside.	No. of Stoves worked.
Jany.	11	49	33		Feby.	14	55	45	
„	13	49	44		„	15	54	43	
„	14	52	45		„	17	52	37	
„	15	53	41		„	18	52	38	
„	16	52	40		„	19	53	39	
„	17	51	38		„	20	53	39	
„	18	52	37		„	21	52	41	
„	20	48	31		„	22	52	34	
„	21	48	32		„	24	50	36	
„	22	49	35		„	25	50	37	
„	23	48	32		„	26	50	38	
„	24	48	35		„	27	53	40	
„	25	49	34		„	28	53	44	
„	27	48	37		Mar.	1	54	34	
„	28	49	32		„	3	52	42	
„	29	50	35		„	4	53	46	
„	30	51	34		„	5	56	53	One Stove on.
„	31	51	35		„	6	54	45	do. do.
Feby.	1	52	33		„	7	55	46	do. do.
„	3	49	40		„	8	56	47	
„	4	50	39		„	10	55	48	
„	5	51	39		„	11	56	45	
„	6	53	46	One Stove on.	„	12	56	50	
„	7	56	48	do. do.	„	13	53	37	One Stove on.
„	8	55	44	do. do.	„	14	52	36	do. do.
„	10	55	48	do. do.	„	15	53	44	do. do.
„	11	57	44		„	17	51	41	do. do.
„	12	55	41		„	18	55	47	do. do.
„	13	55	40		„	19	55	45	do. do.

1879.		In the Room.	Outside.	No. of Stoves worked.	1879.		In the Room.	Outside.	No. of Stoves worked.
Mar.	20	56	47	One Stove on.	Mar.	27	50	38	
„	21	54	45	do. do.	„	28	51	38	
„	22	50	41	do. do.	„	29	54	48	
„	24	48	36	do. do.	„	31	52	47	
„	25	49	35		Apr.	1	54	48	
„	26	50	39						

The coke consumed, with the cost, year by year, is as follows:

		Tons.		£	s.	d.
1874–5	...	28	...	10	10	0
1875–6	...	21½	...	8	1	3
1876–7	...	22¾	...	8	10	7½
1877–8	...	19¾	...	7	8	1½
1878–9	...	31¼	...	11	14	4½
1879–80	...	21	...	7	17	6
1880–81	...	20	...	7	10	0
Total for Seven years		154¼	Costing	£61	11	10½

Or an average cost of £8 16*s.* per annum for fuel.

It will be seen by the section that the three domes are utilised for ventilating purposes. Fresh air can be admitted freely at the windows in the upper clearstory, which are opened easily by a cord, from the floor of the Exchange.

The whole cost of warming and ventilating this building has not exceeded £550.

Concert Hall.

The ventilation of the Concert Hall of this city is on a larger scale than that at the Free Trade Hall. Previous to

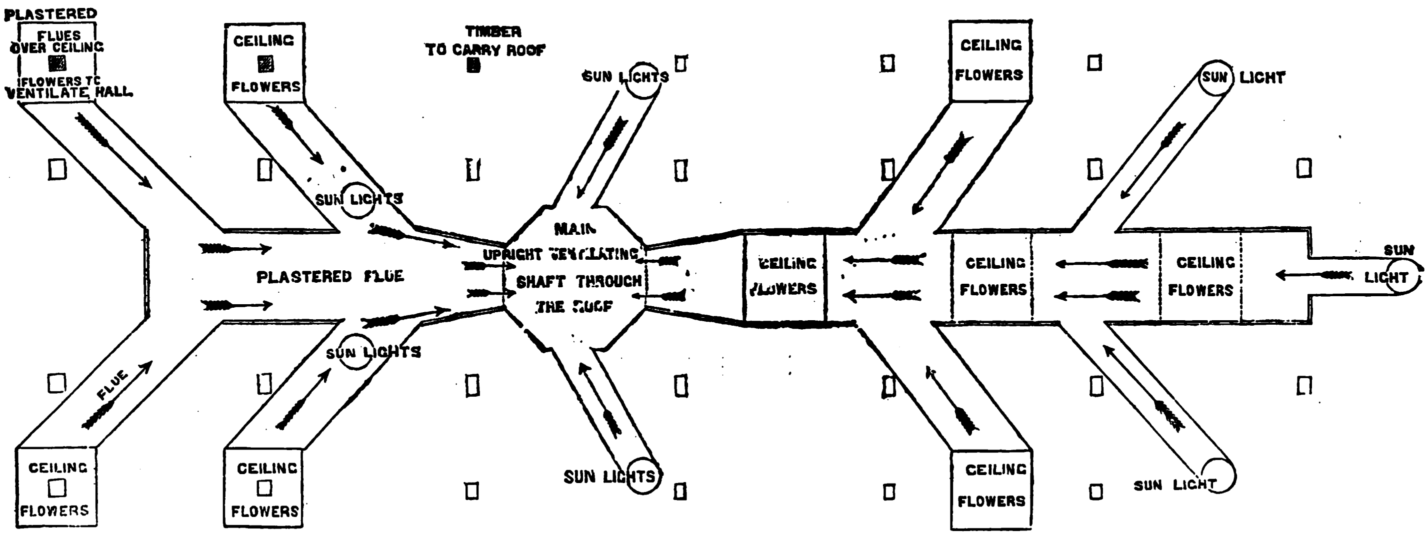


Fig. 11.—Plan of Flues at Concert Hall, Manchester.

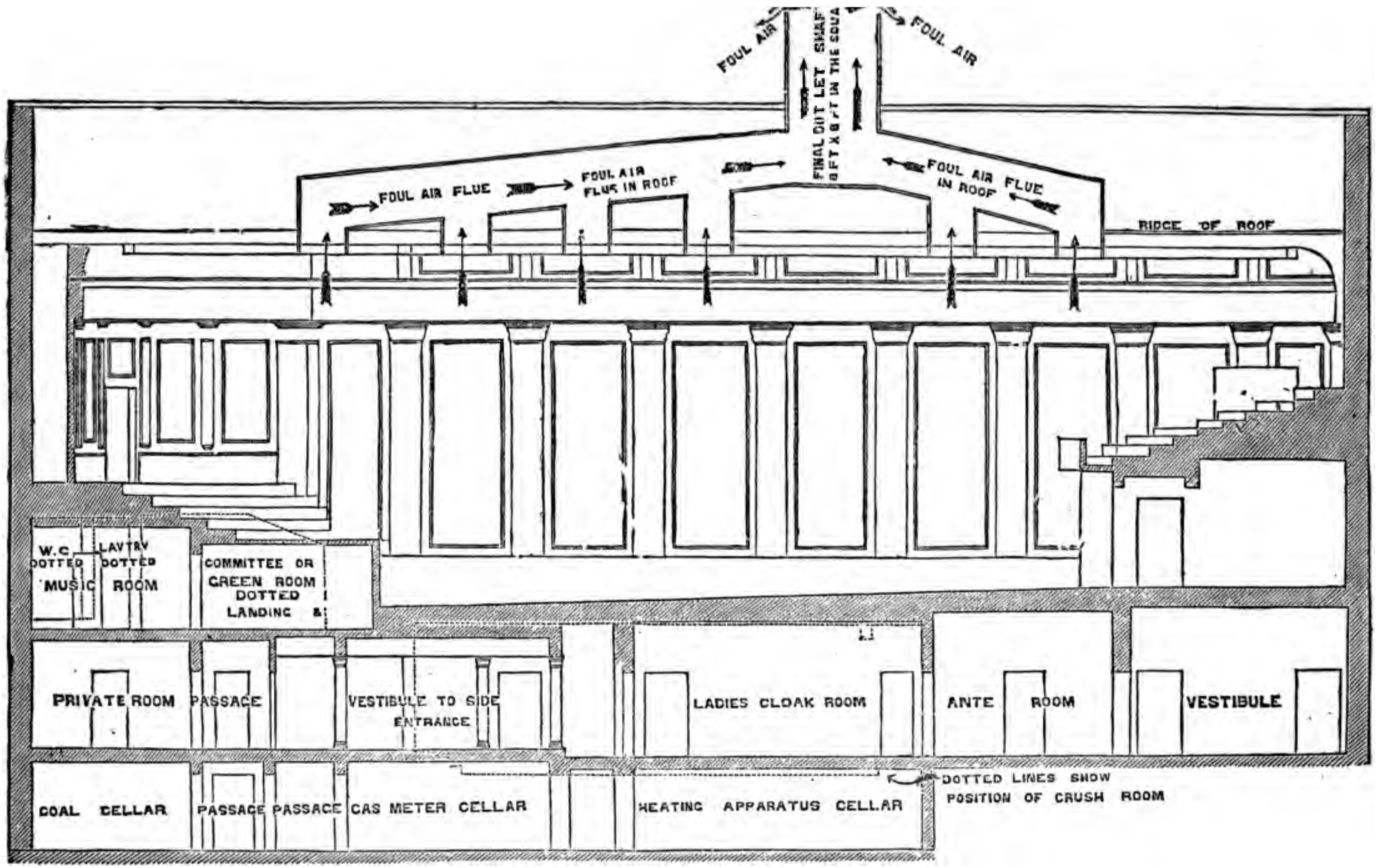


Fig. 12.—SECTION OF CONCERT HALL, MANCHESTER.

the Autumn of 1879 for several years the main out-let shaft had been completely closed, a valve had got wedged fast and had to be broken to make the way clear, so that there was no ventilation. The lath and plaster flues (shewn on plan and section) were then formed, and the result is complete success. As an outlet this is an improvement on the trunk in the Free Trade Hall, the vitiated air being collected from several points and stagnation being hardly possible. This is a simple arrangement and could be readily carried out in most roofs when the lath and plaster flues were constructed. The hot-water apparatus fixed in the basement for warming the large hall and cloak rooms was taken out, and a Convoluted Stove substituted; at the same time a fresh air flue was made to admit cold air from the outside into the warm air flue, which answers the double purpose of giving a supply of fresh air in summer, and mixing it with warmed air in winter, as required.

Theatres.

Theatres are usually erected in central positions of large towns where land is very valuable, and architects have to make the most of the space at their disposal, and to make as many sittings as possible, and usually construct three or four galleries so that on crowded nights the house may be said to be "full from floor to ceiling." Under these circumstances thorough ventilation is a matter of the *first consequence.*

At the Théatre Lyrique in Paris, General Morin, says:

"The vitiated air is taken off through numerous openings in the lower part of the sides of the boxes and passages, and in the risers of the steps in the gallery, each box or

pair of boxes having a separate discharging flue; and the total area of these openings has to be such as to allow the velocity of the air not to exceed 2·3ft. to 2·6ft. per second. The exhausting flues from the several tiers of boxes are made to rise towards the dome above the chandelier, those from the pit, orchestra, and boxes on the ground tier being carried below the floor into main flues leading to vertical shafts, as shown in the diagram; and the area of these exhausting passages should be such as to give a velocity of current of 3·3ft. to 3·9ft. per second. In the pit and orchestra, outlet gratings should be placed all round the sides, and in the sides of the air passages underneath the seats; these outlets open into a space left under the floor, which leads to the main discharging shaft on each side, this space being divided accordingly into two portions. These outlet gratings should not be placed in any case in the floor, as was done in this theatre, contrary to the writer's intention.

"The cast-iron chimney pipes from the heating apparatus are carried up the exhausting shafts to aid the draught, the pipes being kept isolated throughout; and a small firegrate is placed at the bottom of each shaft, for use when extra ventilation is required in summer. The area of these exhausting-shafts is required to be such as to give a velocity of current of 5·6 to 5·9ft. per second; and they should all lead, when possible, to the dome over the centre of the theatre, into which the outlet flues from the upper tiers of boxes also discharge. It is best for a general outlet shaft to be built of brick (not metal) above this dome, and to be carried at least 20ft. or 25ft. above the top, the area of this shaft being such as to give a velocity of current of about 6·6 ft. per second."

General Morin makes a great mistake in carrying off vitiated air in the risers of the steps in the gallery. To take it out at the floor level it has to be brought down amongst the people and much foul air will be inhaled by them.

In all crowded assemblies the vitiated air ought to be carried upwards and out at the ceiling.

With such an arrangement of foul-air flues in the roof as at the Manchester Concert Hall (see Fig. 11), which is simple, effective, and not expensive, all air can be cleared away as fast as it is vitiated. With inlets for fresh air like those at the Free Trade Hall, Manchester, and if the pillars which support the galleries were hollow (every pillar being used as a fresh-air flue) fresh air would be delivered over the heads of the people, and in front of the gallery, draughts would be avoided, and the whole of the air could be changed three or four times in an hour. This plan of delivering fresh air through the gallery front has been carried out with great success in the Lecture Hall of the Young Men's Christian Association, Manchester, under Mr. Price, architect.

With properly constructed and well proportioned flues no valves would be required, and with the heat from the gas necessary for lighting purposes the ventilation could not be interfered with, and both inlets and outlets would act freely in all winds and all varieties of weather both summer and winter. The exhaust shaft should be similar to that at the Concert Hall. (Fig. 12.)

If the building is not warmed in winter there is a very disagreeable back-action caused by the cold walls absorbing heat. To insure efficient heating the apparatus ought to be fixed in the basement. About 12ft. square is sufficient

space for the apparatus chamber. The temperature of the building should be made agreeable before the people assemble, and the heating should be stopped just before the doors are opened. All ventilation is more effective when the building has been warmed.

The Theatre Royal, Manchester, is warmed by a large-sized Convoluted Stove, with flues so arranged that the whole of the warm air can be turned into the corridors at any time.

Churches, Chapels and Schools.

Ventilation is entirely ignored in more than half of the new places of worship now being erected, as if it was of no consequence. This initial neglect of ventilation has brought into use a great number and variety of cowls for the purpose of carrying vitiated air through the roof by a direct opening, and those interested in special cowls have had a harassing time of it, as they have frequently had to fight against nature's laws. For large rooms where great numbers of people assemble, the inlet for fresh air, and the outlet for vitiated air, must form parts of one scheme, or anything like ventilation is utterly out of the question.

Why should not every church, chapel and school have a lath-and-plaster duct in the roof for the purpose of ventilation,—where there is a tower or spire that would form the best possible exhaust shaft? In any new buildings a small tower or turret ought to be constructed for this purpose; it could be made sufficiently ornamental without adding much to the expense, and would often be an improvement to the appearance of an old building.

It will be seen by the section of church (Fig. 14), that

there is ample room in the roof for flues for vitiated air; the tower, or turret, could be placed on any part of the roof most suitable for architectural effect, but not directly over any opening in the ceiling. There is no reason why this should not be done even in open timbered roofs. The inside and the outside lines of roof need not run absolutely together; sufficient space could always be allowed for ventilation. The outlet, and the supply of fresh air, ought not to depend on the opening of windows.

In places of public worship and schools, a constant change of air is essential to health. If the inlet flues are of sufficient capacity, the demand will regulate the supply. It is amazing how air commences to rush through the inlets when a building is filling with people.

The Committee of Council on Education issued "Rules to be observed in planning and fitting up Schools." In these instructions stipulations are made for a certain amount of space for the number of scholars to be accommodated, but there are no instructions or conditions as to change of air or ventilation, and more than half the schools which have been erected under these instructions are really not ventilated at all; one or two openings through the roof, and the opening of the windows occasionally, cannot be considered effective ventilation. These Rules, by the way, may be taken as strong confirmation of the statement made before, that the subject of ventilation has never had its proper place in the public attention, and that no scheme of ventilation has ever yet been accepted as satisfactory "all round."

There is usually an attempt to warm Churches, Chapels and Schools in some form, and the failures are sometimes

lamentable; open roofed churches, with their extensive upper cooling surface, cannot possibly be warmed by either hot water or steam pipes on the floor. Where this has been attempted, failures have been, and of necessity must be, the result. The only effectual method is to throw into them a sufficient volume of warm air to reach and fill every part. When the atmosphere is thus uniformily raised to a genial temperature, alike along the walls, in the galleries, and up to the roof, there will be no cold draughts, and comfort will be insured. Formerly, when hot water or steam pipes were adopted, a system of air warming was carried out. In some cases a large chamber in the basement was fitted with pipes, and supplied with fresh air from the outside, and warm-air flues constructed to convey the air to the rooms to be warmed, as at Pentonville Prison, or flues were made in the room, and the pipes were put in the flues, which were supplied with fresh air from the outside.

In Churches, Chapels and Schools, pipes are often run round the room. In lofty buildings so warmed, there is not much circulation, and the air near the roof remains cold, hence cold draughts. In such places, as soon as the people are assembled, the equilibrium of the air is disturbed, and streams of cold air pour down; nearly every one has had some disagreeable experience of this and often been puzzled as to the cause of these draughts, and when they occur ladies may be seen drawing their cloaks round their necks. From this cause many are deterred from attending,—especially the morning service, and the gas has to be lighted to make the places at all bearable. The same evil tendencies are to be found in places fitted with inefficient air-warming apparatus. One half the places of worship are

fitted with the common "Cockle" stove, and in many cases this does not possess half the heating power necessary for efficient warming, and is wasteful of fuel. This apparatus would show very poor results if fresh air was drawn from the outside, as with a proper apparatus, instead of drawing air from the building and warming it again and again. If any outlet has been provided it is usually closed to allow of the place being warmed. After a time the air is very impure and loaded with carbonic acid, and headaches and drowsiness result. Many places of worship are avoided in the evening in consequence of this.

The annexed plan and section (Figs. 13, 14) show the warming arrangements of a church at Herne Hill, London, where the fresh air is drawn from the outside. Where there is sufficient space under the floor, and there is nothing objectionable in the earth, air may be drawn from thence with grids let into the wall all round the church. This method has also the advantage of ventilating the under sides of joists, &c., and preventing dry rot. This church is most effectually warmed by a Convoluted Stove as shown.

Recently a "Cockle Stove," weighing 14 cwt., was taken out of a church which had an area of 180,000 cubic feet; it was replaced by a Convoluted Stove of 50 cwt. The difference in weight gives the difference in heating power. Every pound of metal has a certain capacity of radiating heat and no more, and the heating power of an apparatus may be readily ascertained in this manner. No one ever thinks of putting down a twenty-horse engine to do work requiring forty-horse power; why then should there be this disparity in heating apparatus? Here seems another

indication that there is no acknowledged basis for adapting warming power to a given area.

In many of the new Board Schools there is no warming except by open fire-places, involving great cost for fuel, as most of the heat goes directly up the chimney.

These open fire-places do not warm large schoolrooms, but, in many cases, they do good service as exits for vitiated air, and in some seasons of the year they are the only means of ventilation.

If the warming and ventilation were considered and formed part of the plan of the building, the large rooms and every class room could be warmed and ventilated to perfection, at moderate cost. See the arrangement of the Manchester Pantechnicon. (Fig. 16.)

It may be that frequent failures in warming have had much to do with the almost general adoption of the open fire-place in Board Schools in this district.

The most complete failure we have seen was at the new Wesleyan Schools, Oakworth, near Keighley, now used as Board Schools. There ought not to have been any difficulty in the matter. The building was substantial, the basement of ample depth, the ventilation good, so that the warm air flowed into the rooms freely. The Schools consisted of large rooms for boys and girls, containing 66,792 cubic feet, concert room 32,640 cubic feet, infants' school 26,880 cubic feet, nine class rooms, united contents 24,297, and corridors 10,164, total 160,773 cubic feet. The firm entrusted with the warming gave a guarantee for efficiency, and must have sustained a heavy loss, as they had to remove at their own cost the apparatus and all the fittings.

This was an attempt to warm the building by hot water

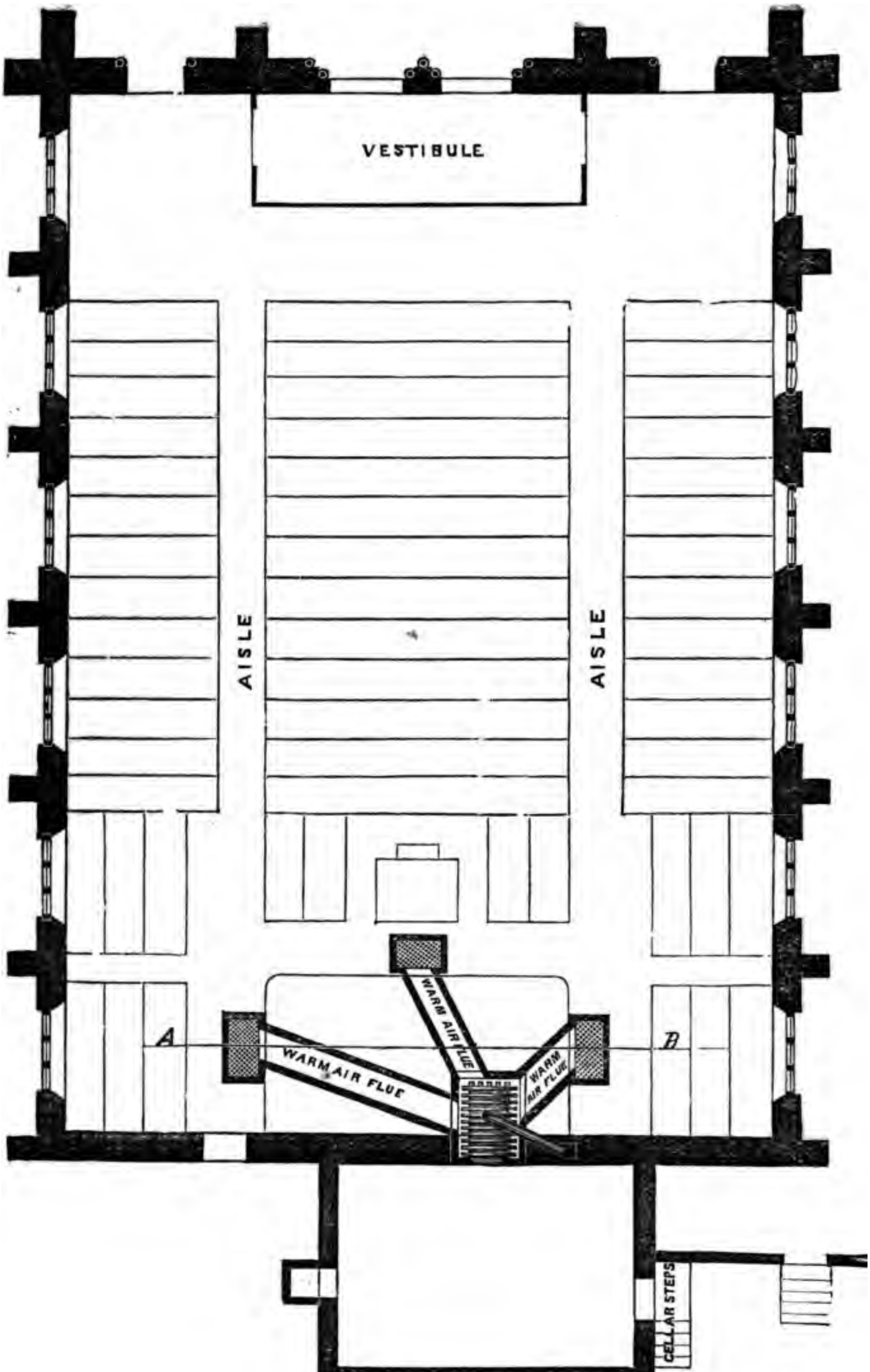


Fig. 13. — PLAN OF CHURCH.

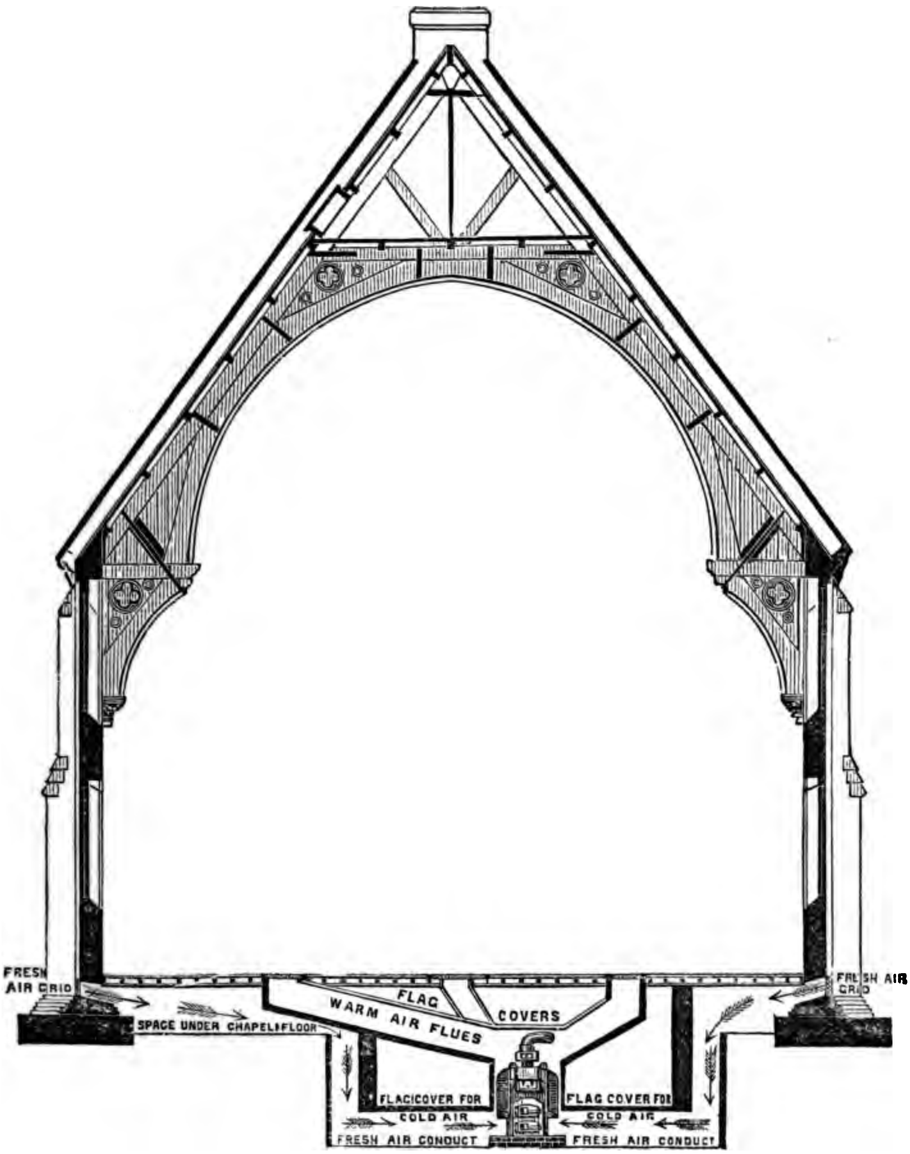


Fig. 14.—SECTION OF CHURCH.

coils and pipes, but failed most lamentably. The substitution of a Convoluted Stove made all comfortable, and the place is now warmed with ease and certainty.

The Manchester Pantechnicon.

The following is a condensed description of this building from the *Manchester City News*, May 4th, 1878:

"The building was erected for the temporary storage of furniture and other household effects, carriages, etc. The plan annexed shews the shape of building and general arrangement. The style of architecture is an adaptation of Italian Gothic, the architects being Messrs. Pennington and Bridgen, London, Liverpool, and Manchester. It has a frontage of 180ft. to Turner Street, and 135ft. in Hadfield Street, in which is the principal entrance. The greater portion of the building is five storeys in height and the area of the floor devoted to storage purposes is 90,000 square feet. Some idea of the accommodation it affords may be formed when we state that there are no fewer than seventy-six different rooms, all of which have been designed with a view to render them best adapted to the class of goods they are to contain. For example, the rooms for the storage of pianos are on the ground floor, in order to avoid the risk of damage to which they would be liable had they to be carried up and down stairs; and another risk provided against is that which results from uneven temperature, an arrangement having been made for maintaining this in a condition best suited for keeping the instruments in order. So likewise in the wine cellars, where a proper temperature is so essential to the preservation of that article, provision has been made

for securing this requisite. The carriage department is conveniently placed at the entrance from the railway, so that carriages sent to be stored can be removed from the truck into that room with the least possible trouble. The building is fireproof throughout, the floors being constructed on the novel principle recently patented by Mr. Hornblower, of Liverpool, and applied here for the first time on a large scale, which consists of rolled iron joists about two feet six inches apart, cased or threaded into springing tiles of fireclay, the interstices being filled with tiles of 'voussoir' shape, resting on the springers, and the whole being floated in with liquid cement. A perfectly rigid floor is thus formed, at the same time precluding the possibility of the ironwork being exposed to the action of fire. The arrangements for heating and ventilating the various compartments have been specially attended to, a powerful apparatus for this purpose, by Mr. Constantine, of Manchester, being placed in the basement, under the loading way. Each room having a separate inlet, the hot air can be shut off as required; and as to ventilation, the special construction of the building ensures a current of fresh air. The entire premises being under cover, the process of loading and unloading can go on irrespective of the weather, and this operation will be greatly facilitated by the railway siding before referred to."

Fifty-three rooms are warmed by the apparatus. On reference to the plan (Fig. 15) it will be seen that two large flues or ducts branch right and left from the stoves in the basement, and are then carried up through several storeys; the warm air inlets to the rooms spring from these in the positions shewn so as each to deliver into one or two rooms; in one case where the plan allowed, four rooms are warmed

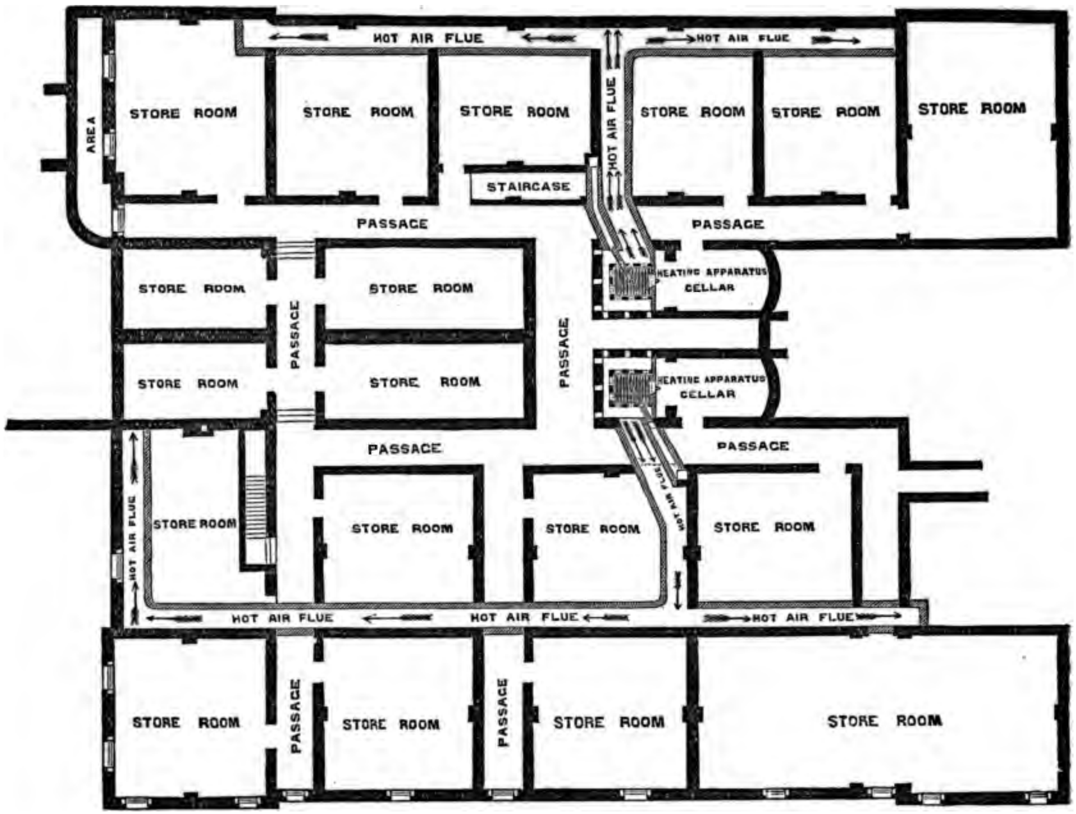


Fig. 15.—MANCHESTER PANTECHNICON. BASEMENT PLAN.

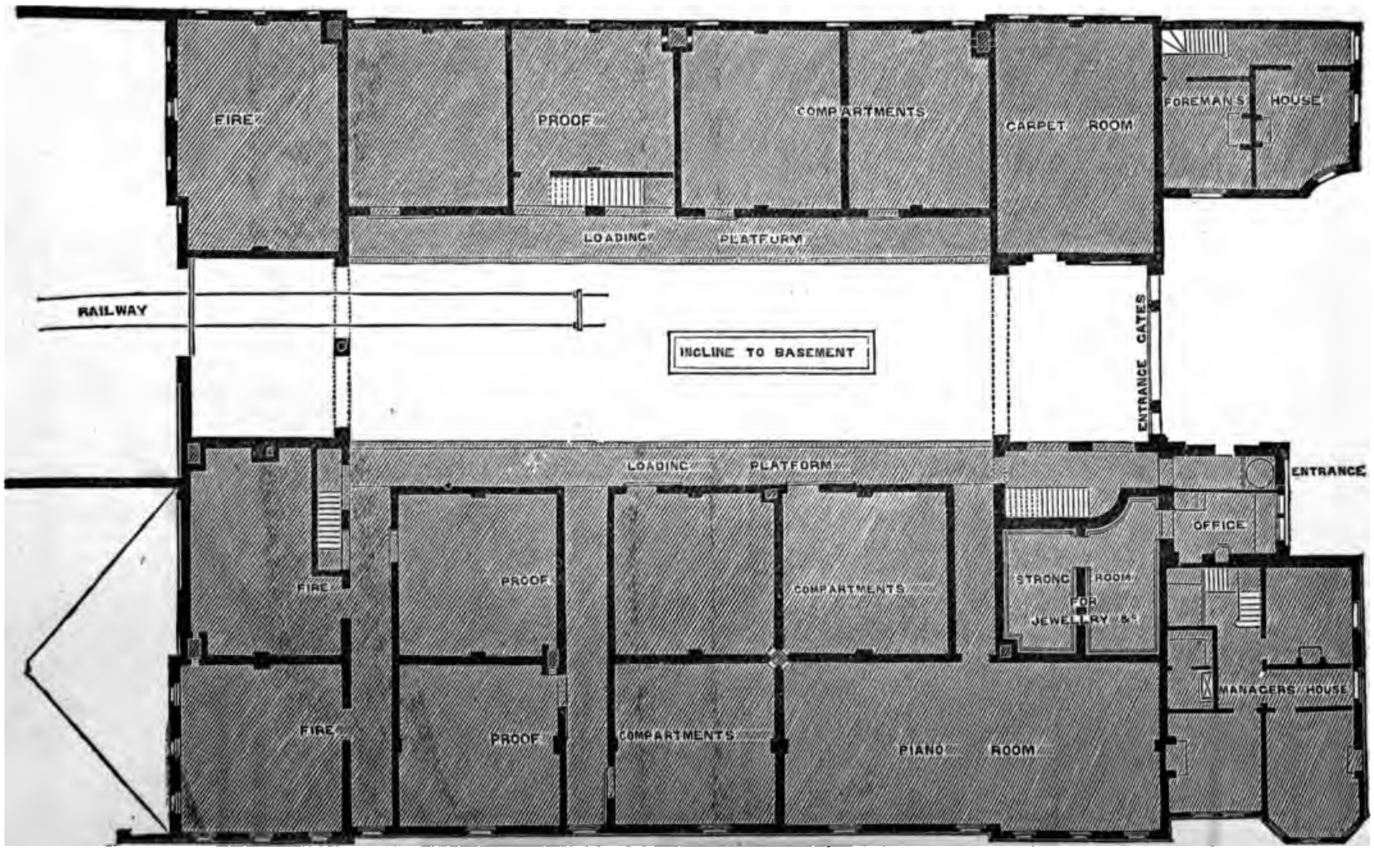


Fig. 16.—Pantechnicon. Ground Floor Plan.

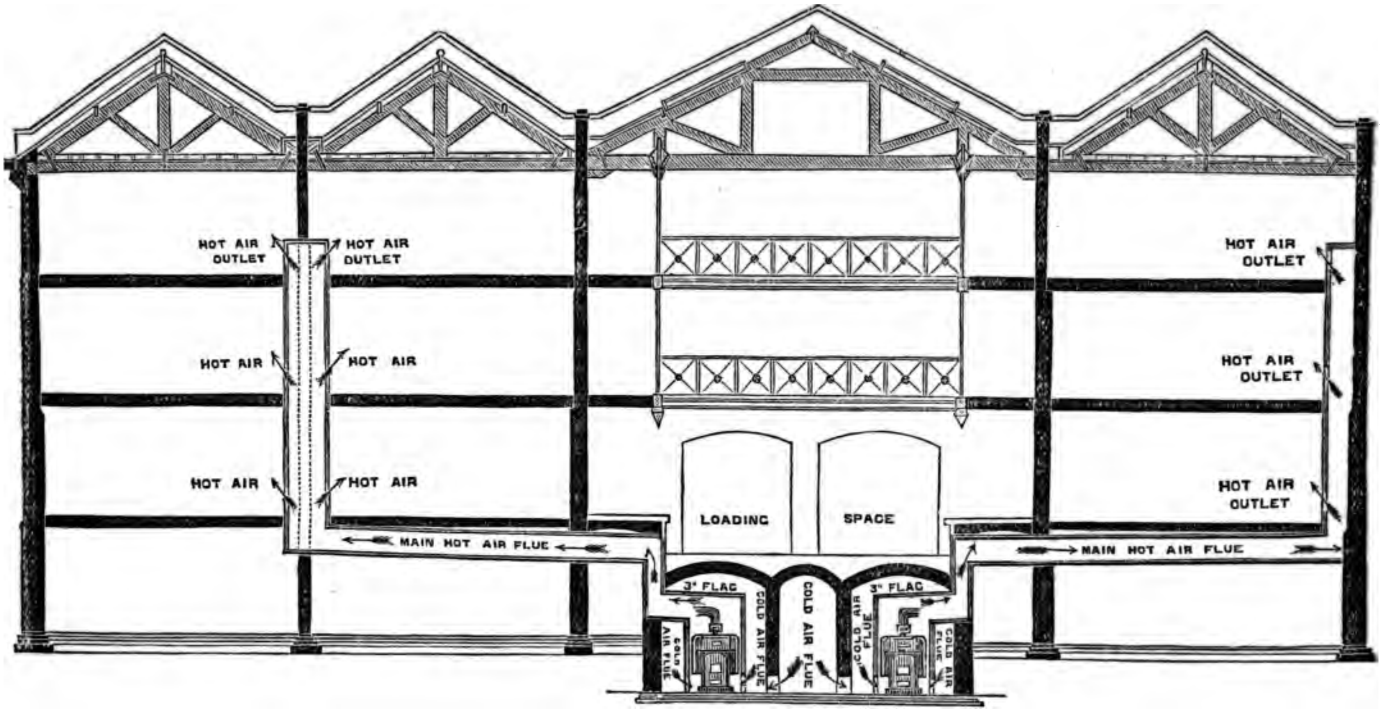


Fig. 17.—Pantechnicon. Section.

from the same flue. Valves are inserted in each room so that the supply of warm air is perfectly under control.

It may be noted that there is no difficulty in making the air travel along these flues, the delivery being perfectly free at the farthest point from the stove and the loss of heat inconsiderable.

The advantages of this system will be seen when it is remembered that it is not a process of merely warming the air in the rooms, but that fresh warm air is carried into them, thus insuring the ventilation so necessary to a building of this description, where every variety of goods is stored.

Coke a/c for Pantechnicon.—Two Winters:

1879 ...	£18	12	8
1880 ...	£10	17	7

Extra firing was required the first winter to dry the building thoroughly.

Mansions, Detached Houses, etc.

Large halls with wide corridors must be warmed to be comfortable in cold winter weather.

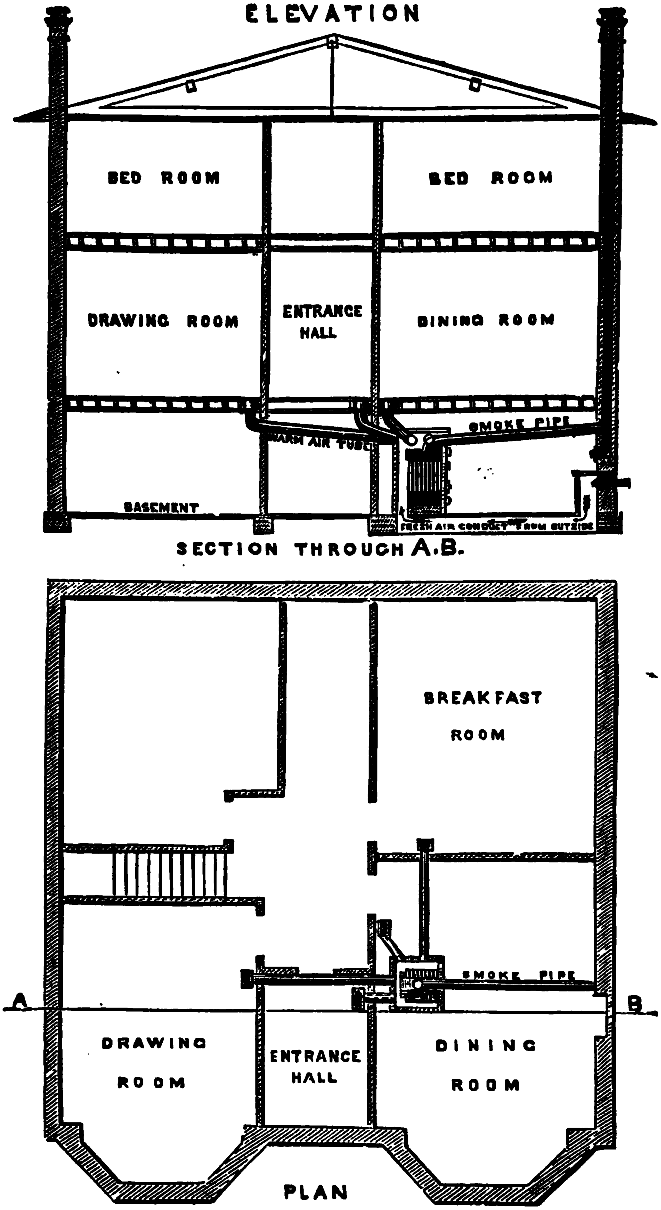
The open fire-place has not sufficient heating power to warm very large rooms, as the radiation from an open fire only extends a certain distance, and does not affect the wall at the opposite end of the room as is necessary to insure efficient warming. Here again we meet with the disagreeable back action of cold air from the cold walls, experienced in churches and chapels which are only indifferently warmed. Anyone drawing near to the fire feels the current of cold air rushing *to* the chimney, and frequently severe colds are con-

tracted in this manner. In large houses a proper system of warming the whole house from one centre is necessary, not for comfort merely, but for the health of the occupants. In large entertaining rooms, which are frequently filled with visitors, good ventilation is essential, and to avoid disfigurement of walls, &c., should be provided for when the building is being erected.

The best warmed and ventilated Mansion we have ever examined is the residence of Isaac Holden Esq. (late M.P. for Knaresborough), Oakworth, Keighley; every room in the house is warmed and thoroughly ventilated, but at enormous expense. The warming is by coils of hot water pipes, the coils are in chambers, each chamber being supplied with fresh air from the outside. Two large ornamental exhaust shafts are erected in the grounds. Connected with these are large underground flues, which collect the vitiated air from the various rooms in the house, also from the Billiard-room, Turkish bath, and Winter gardens, at both high and low levels. Mr. Holden has applied his ingenuity to ventilation as well as to the wool-combing machine which he brought up to its present state of perfection; he has proved, what we had long suspected, that a smoke pipe inside the exhaust shaft is of no advantage whatever, and that the ventilation is improved by allowing the smoke and vitiated air to mix in the shaft.

The exhaust shafts of all the new prisons and many other large buildings are fitted, at considerable expense, with this smoke pipe, which Mr. Holden has proved to be useless, and which is often a disfigurement.

The warm-air system is readily applied to any ordinary-



Figs. 18, 19. — PLAN AND SECTION OF HOUSE.

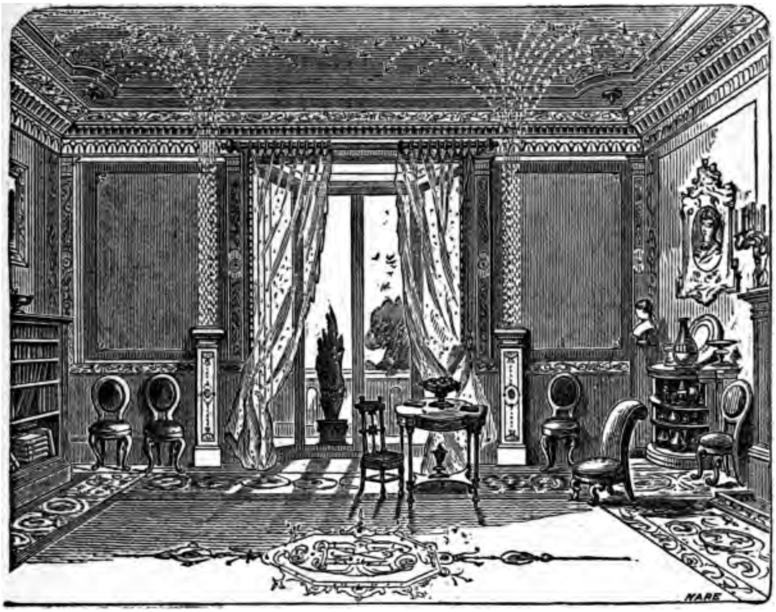


Fig. 20.

sized detached house which is cellared. The apparatus is fixed in the basement, the smoke-pipe taken to the nearest chimney, and a separate delivery of warm air to the dining-room, drawing-room, breakfast-room, and the hall; from the hall the warm air finds its way to the bed-rooms and raises their temperature eight or ten degrees. The plan and section (Figs. 18, 19) show the arrangement. An apparatus with four deliveries fixed as shown will not consume more fuel than one open fire-place; the fire will remain good through the night, so that the rooms are never cold even in winter.

Where no ventilation has been provided the ordinary chimney flues act as ventilating shafts. If a cavity is formed in the outside walls, the various rooms may be

ventilated into it; the outlet from the cavity ought to be made at a high point, underneath the eaves. It is a very good rule to have the bedroom windows slightly open both day and night, and have them fitted with a high bead as shewn. (Fig. 5.) Fresh air from the outside will then be admitted without draughts.

It is a great advantage to admit fresh air directly from the outside if it can be diffused so as not to cause draught. The London Ventilating Co. have succeeded in this by means of the vertical tubes shewn in Figs. 20, 21, 22, and by the ornamental bracket shewn in Fig. 23. These may be fitted in any convenient position, and the air on entering is deflected over a trough of water, as shewn in Figs. 22 and 23, to cleanse it from "smuts" or organic impurities.

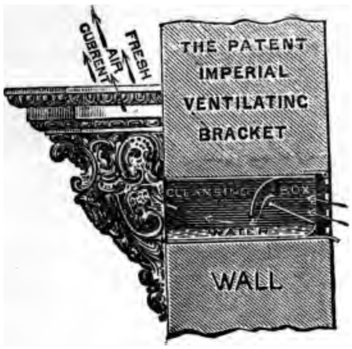


Fig. 23.

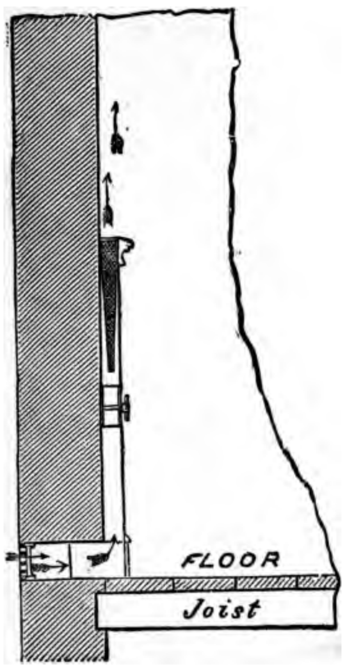


Fig. 21.

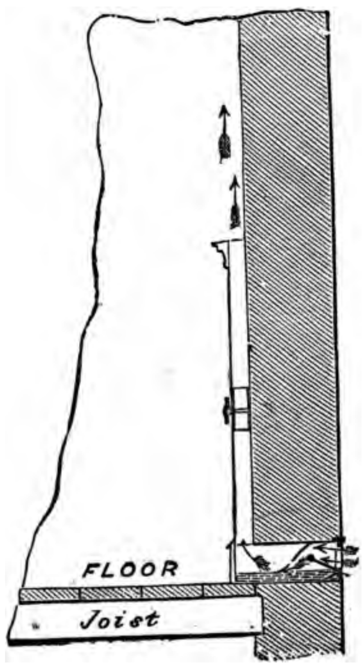


Fig. 22.

The Turkish Bath.

The Turkish or hot-air bath has been used from time immemorial in the East, and has no doubt been the sanitary salvation of numbers of Orientals, whose indolence has prevented the observance of any proper Hygienic laws in their dwellings. We are indebted to the late David Urquhart for the introduction of the Turkish bath into this country. It has now become a permanent and valuable institution, and nearly every large town in England has one or more Turkish baths of some sort. Several Hospitals and Infirmaries have them, and no Hydropathic establishment can be considered complete without both ladies' and gentlemen's baths. Many gentlemen, following the example of the Right Hon. John Bright, have fitted up private Turkish baths.

The original baths were heated with smoke flues traversing beneath the floor, which was made so hot that it was not safe for bathers to walk on without slippers or wooden shoes. With the bath so heated ventilation is out of the question. Even now there are in this country a few Turkish baths heated partly by the smoke flue under the floor and traversing zig-zag in the wall of the hot rooms, and partly by the "Cockle" stove (hereafter to be described). By this mode of heating several baths have been burnt to the ground, and it is objectionable in other respects; soot accumulates in the flues and is troublesome to clean out from time to time.

Perfect ventilation is of the greatest consequence in the Turkish bath — the object of the bath being to quicken exhalation through the pores of the skin — stagnant air soon becomes loaded with impurities and most offensive. This idea of thorough ventilation being possible in the

Turkish bath seems to have been startling to some of our scientists, who really ought to have known better. *The Lancet*, in an article dated June 5th, 1880, says:

"Now that the hot-air bath has been fairly naturalised in England it is necessary to examine the institution critically. One of the most obvious sanitary conditions of the bath, but, unfortunately, that which is most difficult to secure, is the purity of the atmosphere in which the breathing organs of persons in a peculiarly susceptible physiological state are immersed. The breather of impure gases under ordinary circumstances takes his poison largely diluted. If the air of a Turkish bath is laden with germs of disease thrown off from the lungs of a fever or a consumptive patient, there are no currents to carry the particles away. It is a physical certainty that others breathing in the bath must inhale them. This is an evident source of peril, and suggests the wisdom of taking measures to ensure the frequent changing of an atmosphere which may be thus easily polluted."

Over twenty years ago the Author was impressed with the importance of supplying a continuous stream of hot fresh air, with suitable outlets for vitiated air, and he then rejected the method of merely heating the air in the bath without a constant change. Before succeeding in his object a great number of heating apparatus were tried and abandoned. The difficulty of finding a suitable and durable apparatus chiefly led to the invention of the Convoluted Stove. By its use and the system of outlets shown on Plate No. 24 the air can be changed as often as desired —there being always a continuous current of fresh warm air.

Mr. J. L. Bruce, architect, Glasgow, in a paper read before the Philosophical Society of that town, April 30th, 1879, on the Heating and Ventilation of Turkish Baths, gives the following description of the Arlington Baths, and his experiments on the heating and ventilation of the same :

"The Arlington Turkish Bath is arranged in a ⊥ shaped group, the cross part being formed of the cooling, hottest, and hot rooms, and the body of the shampooing and washing rooms, the latter communicating directly with a large swimming pond.

"Starting from the cooling room at the right hand end of the ⊥ passing through double doors, and drawing aside a thick curtain, the hot room is reached, 29ft. 3in. square, with a domed ceiling 23ft. 6in. high. This room is lighted by a large number of star-shaped openings filled with stained glass and double-glazed. On the side next the hottest room, and opening to it, are three large arches, and a door similar to the curtained door referred to. The lower parts of the arches are closed with clear plate glass, the central one of the three being made to open on vertical pivot hinges. The top parts are left unglazed to admit of the free passage of air.

"The hottest room is an apartment 23ft. long by 10ft. 6in. broad and about 12ft. high to the arched ceiling. Light is obtained partly by a square opening in the centre of ceiling, and partly by the three arches already described.

"The shampooing-room door is situated outside of the curtained opening at entrance to hot-room from cooling-room, being cut off from the latter by the double doors — this room thus occupying the vertical portion of the ⊥ nearest the hot-room.

"Beyond the shampooing-room, and opening off it, is the washing-room, which again communicates directly with the main bath by means of a small branch or plunge, which projects so far into the floor. The space in the wall over this plunge is filled in with plate glass, the upper part being made to open so as to regulate the current of air passing through. From this description it will be seen that, commencing with the hottest room, all the apartments open one off the other (of course excluding the cooling-room). This arrangement — specially adapted for the method of heating and ventilation employed — at least possesses the advantage of extreme simplicity. Under the end of the hottest room furthest from the door are placed two large hot-air stoves. Fresh cool air from openings in basement flat passes over the heating surface of these stoves, and ascends through the grating immediately over the apparatus, into the hottest room, from thence passing to the hot-room by the open tops of the three arches, then through the curtained door by way of the shampooing-room and washing-room to the large bath room, from whence it finds exit to the open air by the main central ventilator. In adopting this method a very large body of air must be thrown through the rooms to secure the requisite purity at the further end of its course, and as a natural consequence, a very great heating power must be provided to maintain the high temperatures necessary.

"In ascertaining the actual state of matters, my first difficulty was caused by the high temperature of the air delivered through the gratings in hottest room, viz. :—312° and 260° Fahr. I found it impossible to endure the strong current at those temperatures, and for that reason, and be-

cause of danger to the anemometer, the attempt to test the currents at this point was abandoned.

"But the amount of air was exactly measured at the points where it enters the heating apparatus (chamber) in the basement flat. The temperature of the entering air was 52°, the amount for *first* stove being 790 cubic feet per minute, heated by stove to 312°, and for *second* stove 558 cubic feet, heated to 260°—in all 1,348 cubic feet entering at 52°. The actual amount of heat-expanded air entering the hottest room is readily obtained from these data by a well-known formula, which gives for stove No. 1, 1,192 cubic feet, and for No. 2, 788·7 cubic feet—in all 1,980·7 cubic feet per minute.

"Giving even double the usual *sleeping*-room allowance of 20 cubic feet per head per minute—that is, allowing 40 cubic feet per head—this is sufficient for 50 people in those rooms, and seems enough for all practical purposes. With this enormous volume the temperature maintained in the hot-room is about 144°, and in the hottest room 210°—the latter being readily raised to 230° by closing the lower part of central arch between the two rooms.

"To obtain the direction and speed of the currents through the three arched openings, two observations were taken, which, though roughly done, still give some idea of the truth. With the glass of central arch standing full open, there was a current of 60 lineal feet per minute through the clear space at top, from hottest room to hot-room, and a reverse current of 68 lineal feet per minute at the bottom of open pane, thus giving a double circulation through the hottest room of hot-air to hot-room at top, and cooler air to hottest room at bottom. These currents of

course readily account for the increased temperature observed in the latter room when the glass pane is closed.

"A test was made of air passing through hot-room door to shampooing-room. This door is 7 feet high. The following readings were obtained :—

At top, 374 lineal feet per minute at 160°.

Middle, 192 „ „ at 140°.

Bottom, 25 „ „ temperature not taken.

It may be interesting to note, that in the comparatively still air of the hottest room, a temperature of 210°, and even more, could be endured without pain ; but where there was a strong current, the air, though of lower temperature (as for example, at the top of the door just referred to) produced a sharp, smarting feeling on the more tender parts of the skin, which became almost unbearable after a couple of minutes' endurance.

"The heating and ventilation of those rooms, as described, is obtained at a consumpt of from 48 to 60 cwt. of gas coke per week of 55 hours.

"The cubic capacity of the hot and hottest rooms is about 17,770 feet, giving a proportion of one square foot of cast-iron heating surface in stoves to about 23·8 cubic feet of contained space.

"These are the principal facts as to the arrangements and ventilation of the rooms at Arlington.

"The heating apparatus consists of two of Constantine's large Cast-iron Patent Convoluted Stoves. They may be described as oblong "Gill Stoves," with the gills made hollow, which provide an enormously increased heating surface, and allow play for the expansion and contraction of the metal, and thus avoid the chance of ruptnre to which the old

fashioned "gill stove" is so subject when used for high temperatures. Each stove is about six feet long, and comprises twelve hollow gills or "convolutes," as Mr. Constantine calls them, set side by side, and enclosing a fire-box space of about 77 cubic feet, the grate space at the bottom of this occupying about 750 square inches. The products of combustion rising from the fires are directed against the iron convolutes by a flat fire-clay plate, placed across the fire-box about two-thirds up, and afterwards pass away into the smoke-box at top, and thence by the smoke-flue (at top of smoke-box) to chimney.

The proportion of stoves is as follows:

Grate space to radiating surface, in feet, 1 to 56·8.
lbs. of coke burnt to heating surface, in feet, 1 to 6.
Grate space to capacity of fire-box, in inches, 1 to 17·8.
Heating surface to cube contents, in inches, 1 to 3·1.

The total heating surface of each stove is 296 square feet, and the radiating surface 77·9 square feet.

The work actually done by each stove in warming air is as follows:

No. 1 stove—1,192 cubic feet of air thrown into room at 312° Fahr., outer air being at 52°, difference 260°. By multiplying the cubic feet of air by its weight in pounds per cubic foot at 312°, and by its specific heat per pound, which is constant at all temperatures, and by the number of degrees Fahr. that the temperature of the air is raised—the heat units per minute are given as under, and these, multiplied by 60, give the units per hour.

G

No. 1 Stove.

1,192 cubic feet raised to 312°,

3,465·28 units × 60 = 207,916·8 units.

No. 2 Stove.

788·7 cubic feet raised to 260°,

2,147·39 units × 60 = 128,843·4 „

A total of 336,760·2 „

To produce this result the consumption of gas coke is 60 cwts. in cold, and 48 cwts. in warm weather. The temperature being at 52° during these observations, the latter amount has been taken, giving 97·7 lbs. of coke consumed per hour, or 48·8 lbs. per stove.

The heating power of coke, when fully burnt with sufficient air, is 10,970 units per pound. This consumption, therefore, yields 1,071,769 units per hour for both, or 535,844·5 units per stove. This shows that 735,009 units of the coke used per hour are wasted, so far as the heating of air is concerned. Partly by radiation through brickwork casing, &c., partly by imperfect combustion of coke (too little air being supplied), and partly by over-firing, a great part of the heat is sent up the chimney.

The great waste at present taking place is amply confirmed by the condition of the cast-iron smoke pipe leading to the chimney, for it is almost at a red heat about four feet from the stoves. There is also no doubt that considerable waste is taking place through the formation of carbonic oxide from an insufficient supply of oxygen to the coke, as the air passing into fire is only 157·3 instead of 269 cubic feet per pound of coke. These facts show that at present two-thirds of the fuel employed is wasted, so far as useful

result is concerned; but this is without doubt due in a large measure to carelessness and over firing of the stoves.

To ascertain the amount of fuel which should be consumed in those stoves, if economically used, I made a calculation of the utmost amount of units each stove was capable of giving off without undue waste up the chimney. Taking the heating surface of stove at 750°, the average heat of traversing air at 120°, and considering the brick casing of stove as receiving the radiated heat from the iron surface and imparting it to the air by contact, its surface being at 650°, this gave theoretically, as imparted by contact to the air, 235,503 units per hour. This amount corresponds fairly with the actual units of work done by stove No. 1, which is 207,916·8, but is far in excess of the work done by stove No. 2, which shows only 128,843·4 units.

However, taking units usefully used as above—

	235,503 units per hour.
Adding for loss by radiation through brick casing, say 322 units per foot, ×77·9	25,083·8
Total............	260,591·8

doubling this for both stoves, and dividing by the units per pound of coke, we see that for the above units 47·5 pounds are necessary. To provide sufficient draught in the chimney, 4½ additional pounds are wanted, making in all 52 pounds of coke necessary to furnish all the units the stove has surface for. Give allowance for waste by radiation, and send the products of combustion up the chimney at a temperature of about 250° so as to insure a proper draught. Of course I am not prepared to say that the result presently

obtained in the hot-rooms could be obtained using only 52 pounds of coke per hour; but I have no doubt that the present absurdly-large consumption could be very much reduced by contracting the area of the fire-grate and by careful regulation of the dampers. It is obvious from these calculations that the heating surface of the stoves is quite inadequate to give off to the surrounding air even one-half of the heat at present generated in the fire-box. The result is that at least 45 per cent. of the fuel goes to heat the air which passed off in the smoke flue and is simply wasted.

Apart from the disproportion between the grate space and heating area (which may be put right with a few bricks), Mr. Constantine's stove seems an excellent one, and possesses in a high degree the advantage of extreme simplicity and durability; qualities so important in apparatus of this kind, which are generally under the charge of comparatively ignorant men. I may mention the result of an experiment, showing the loss of heat by radiation and conduction through the walls, &c., of the hot-room at the Arlington bath. Advantage was taken of a time when the baths were not in use, and the stoves consequently not in use; all the entrance and exit openings for air were carefully closed, and the enclosed air so imprisoned as it were. The temperature outside was 47°; by thermometers hung on the walls inside the rooms the following temperatures were indicated—

At 12 o'clock noon, 92°
At 5 p.m. .... 88°

Showing a loss of 4° in five hours.

Allowing that the contained air would remain at the

same temperature as the surrounding walls, and taking the loss of heat throughout the mass of air, together with the cubic contents of the walls, there was a loss in all of about 7,968·6 units per hour, or 2·2 units per cubic foot of contained space shown by this difference of temperature."

The large hot-room in these baths, it will be seen, is really twice the necessary height, and hence there is great waste of heating power. Again, heat could have been greatly economised by forming an air cavity in the walls instead of their being built solid. The grate space in the Convoluted Stove could be readily reduced as Mr. Bruce suggests, but to maintain the high temperature required for a Turkish bath a large margin of heating power is desirable beyond the bare requirement. This margin of power also contributes to the durability of the apparatus — hard-firing not being required, even when the apparatus has been temporarily neglected.

Mr. Bruce's experiments at the Arlington baths are given at length, as they are the best of the kind on record, and may induce and assist other experiments. They also show that there is no difficulty in ventilating Turkish baths.

In the construction of a Turkish bath, the arrangement of rooms, &c., and the position of apparatus, will be governed a good deal by the shape and surroundings of the ground to be covered, as well as by the space at disposal. A number of the London baths are badly situated in these respects, in some cases the hot-rooms being underneath, or considerably below the cooling-rooms. It is much better to have these rooms on the same level, avoiding steps and making the place more comfortable for gouty, rheumatic and feeble persons generally.

In towns where land is very valuable three storeys of Turkish baths may be constructed, the floors being concrete, and the whole can be well heated with one apparatus. For Hydropathic establishments, where two baths are required, the ladies' and gentlemen's baths may be constructed side by side, as shewn on Figs. No. 24, 25.

The size of bath should be in proportion to the number of bathers likely to use it at one time. It is advisable to have the cooling-room thoroughly well ventilated and of ample dimensions, especially in Hydropathic establishments, where many other baths are administered in the shampooing-room, such as the sitz, rain, douche, shower, &c.

The annexed plan and section (Figs. 24, 25) shew a double bath with ample room for twelve each, ladies and gentlemen, heated with one apparatus. The relative sizes of rooms are given from experience. It may be thought that the hottest room is rather small, but a large proportion of bathers never use it, the first room being a sufficiently high temperature for them. In a number of baths there are three hot rooms, but experience shews this to be unnecessary; some bathers will perspire sufficiently in the shampooing room with a temperature of 135°.

The inside walls should be constructed of glazed bricks, and the various colours in which these are made will allow of any required amount of ornamentation. The sketch shews brown walls with a white dado, finished with moulded brick string, but diapers of any colours can be easily introduced. The ceiling light also may have marginal lights of stained glass, &c. Gas ceiling lights should have a tube over connected with the cavity in the wall, so as to carry off the products of combustion, or with glass lights the gas might be altogether in the roof.

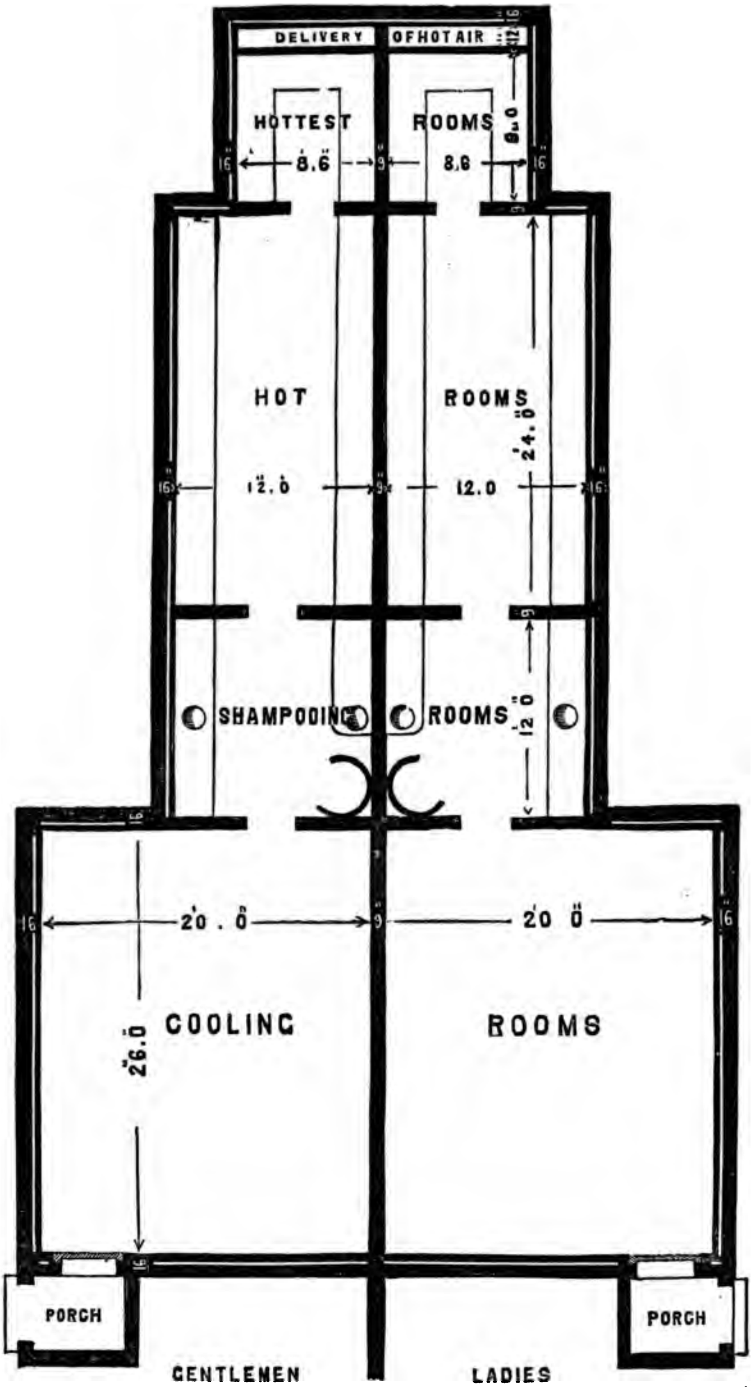


Fig. 24.—Plan of Turkish Bath.

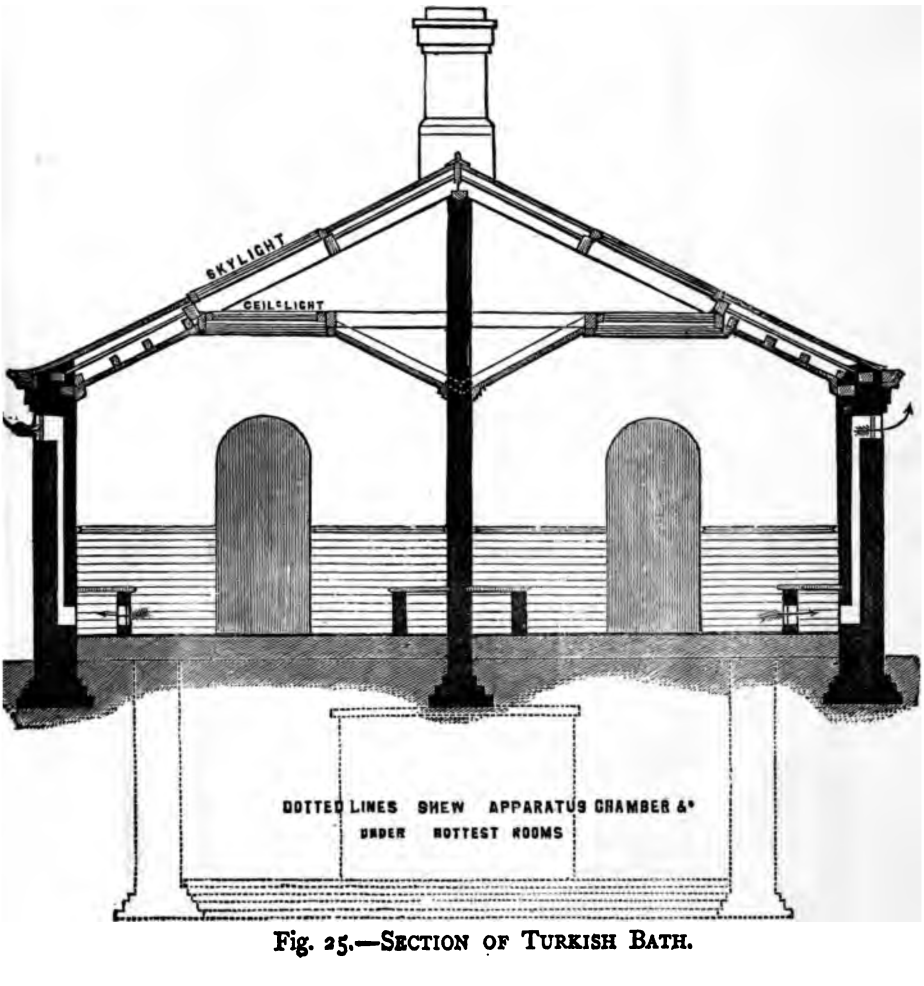


Fig. 25.—SECTION OF TURKISH BATH.

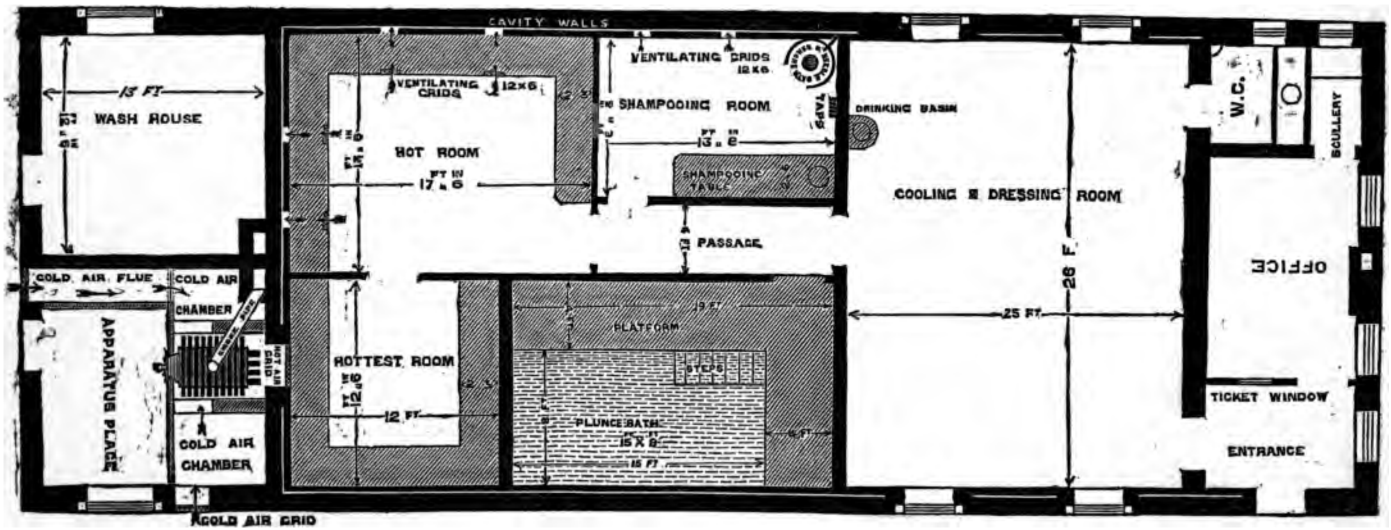


Fig. 26. — PLAN OF TURKISH BATH WITH PLUNGE.

The floor of the shampooing-room, where water is used freely, should be of cement, as tiles become too slippery with the soap and wet. The remainder of the hot-rooms may be tiled, but the cooling-rooms should have a boarded floor.

It will be noticed that the hot air is delivered behind the marble slab in the hottest room; this delivery is best at about five feet above the floor.

In plate 26 is shewn a plan of bath intended for the coast, where no basement is available, but where a plentiful supply of sea water is at hand for the plunge bath shewn; the apparatus here is of course on the same level as the bath.

Disinfecting Rooms.

Disinfecting rooms are now provided in connection with all workhouse casual wards. In most prisons and hospitals, too, they are necessary. The quickest and most effectual disinfectant is air heated to at least 210° Fahr. The late Dr. Henry of Manchester (a contemporary of Dr. Dalton), seems to have been the first to discover and apply the disinfecting power of heat. In a paper contributed to the *Philosophical Magazine* in 1831, he says: ". . . . . . . that the infectious nature of cowpock was inert at 140°, and three flannel waistcoats which had been worn by a patient in the Manchester fever ward were subjected separately for an hour and three quarters to a temperature of 204° or 205°. The first waistcoat was kept within twelve inches of the nostrils of a person who was engaged in writing, for two hours. The second waistcoat was worn next the skin by the same individual for two hours. The third was kept in an air-tight tin canister for twenty-six

days, with the view of giving increased activity to any contagious matter that might have escaped decomposition. It was then placed within twelve inches of the face of the same person for four hours, and a gentle current of air being contrived to blow upon him from the flannel during the whole time, but no injurious effects were experienced. Prior to these experiments the individual was much fatigued by exercise and had fasted eight hours—circumstances most favourable for contagion, if any existed."

In 1832, Dr. Henry describes further experiments thus:

"The other experiments were made with several cases of the worst form of scarlatina (*scarlatina anginosa*).—Flannel waistcoats worn by the patients during the various stages—the efflorescent stage in particular—were treated one, two, three, and four hours, at temperatures from 200° to 206°. They were worn by various children from three to twenty-two days, without the slightest injury or unfavourable result." The names of the patients and the details are given by Dr. Henry, but they are far too lengthy for insertion here. It should, however, be mentioned, that it was ascertained by the most careful enquiries, that the children to whom the disinfected waistcoats were applied, had never been affected with scarlatina, and were therefore liable to that disease. The children were attentively examined, from day to day, in order that no slight symptom might pass unobserved.

Dr. Henry states that "the preceding cases of typhus are not entitled, from their fewness, to the same weight as those of scarlatina, in illustrating the disinfecting power of heat, because the latter were so much more numerous, varied, and complete." Of the last he remarks that "*they prove*

that by exposure to a temperature of not less than 200° *for* ONE HOUR, *the contagious matter of scarlatina is either dissipated or destroyed.* It seemed more probable that it was *decomposed,* than *volatilized,* because cowpock matter, though completely deprived of its volatile matter at 120°, was not rendered inert by a temperature much below 140°." Dr. Henry further remarks that the disinfecting power is due to heat alone, as there was no opening in the apparatus to allow the escape of contagious matter, or for the atmosphere to act in its expulsion.

The heating and ventilation of Disinfecting rooms and Drying rooms should be very similar to that shewn for Turkish baths. Cavity walls with ventilation from near the floor level, through the cavity, economize heat, as the cooler air is taken out of the room. There is usually a difference of some fifty degrees between the air at the ceiling and that at the floor level. Ventilation from the top of the room thus takes away the hottest air, which will make the shortest possible passage from the inlet to the outlet. We have seen drying-rooms in connection with large manufactories with the ventilation at the top of the room wasting about half the heating power, and thus causing an unnecessary consumption of fuel.

All the outside walls ought to be built with a cavity of two inches; the inside portion of walls should be glazed bricks, which admit of thorough cleansing, and there should be as few projections or breaks (where dust can lodge) as possible.

Disinfecting rooms are usually of fire-proof construction with iron doors, the floors of concrete finished with cement, and it is an advantage to have the roof of the same, with a

smooth cement ceiling. As shewn on plan, a small division, into which all the hot air can be directed, is most convenient for clothes and small articles, which can be disinfected immediately.

In the case of a hospital or asylum with a Turkish bath attached, a disinfecting room could readily be arranged close at hand, and one heating apparatus will do for both—the heat being directed to one or the other by means of dampers.

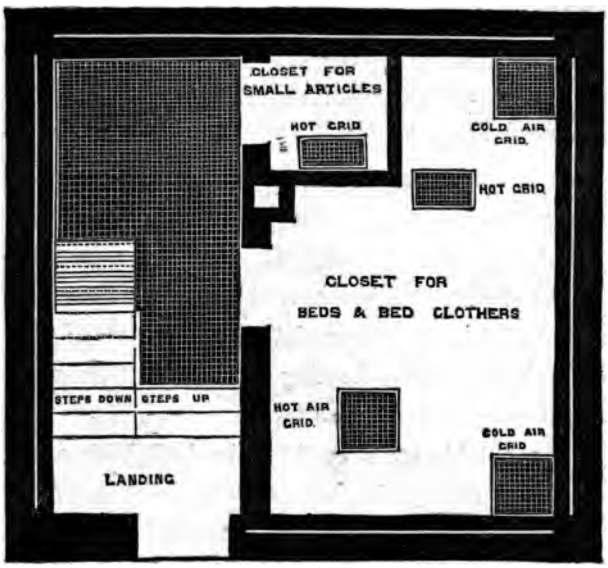


Fig. 27.—PLAN OF DISINFECTING ROOM.

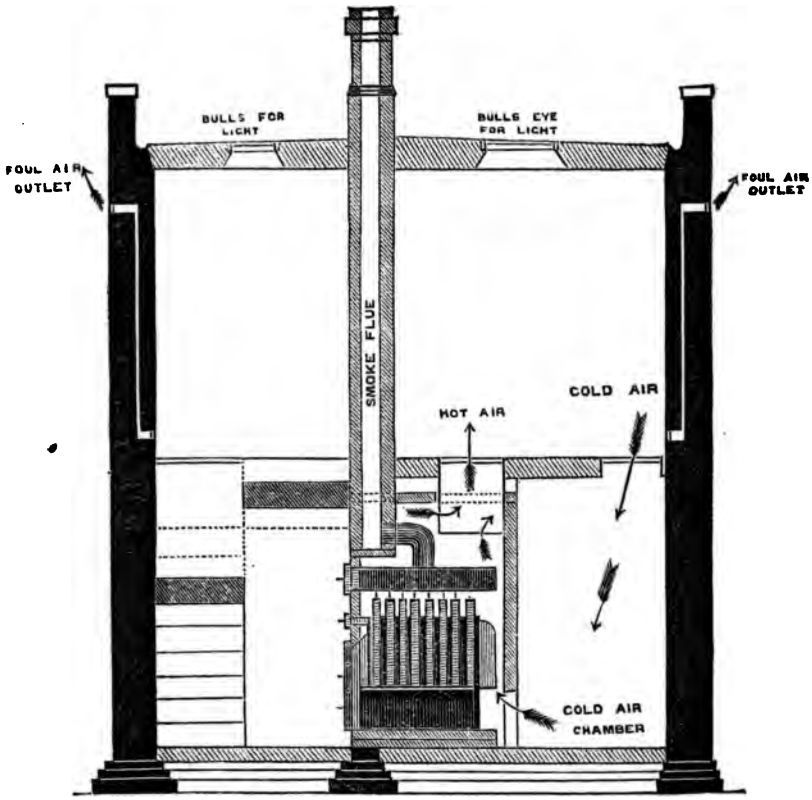


Fig. 28.—SECTION OF DISINFECTING ROOM.

CHAPTER II.

Ventilation of Stables and Cattle Sheds.

HORSES and cattle require pure air as well as man, but in much larger quantity. Dr. Parkes, in his *Practical Hygiene*, says, "The amount of ventilation for animals has not been experimentally determined to my knowledge. A horse is said to require at least 2,466 cubic feet of fresh air per hour, but he probably requires more, and the analysis of the air of stables shows that the air has frequently been very impure. At present, the army regulations allow, in new stables, each horse 1,605 cubic feet, and 100 square feet of floor space; and the means of ventilation, as will be presently noticed, are ample. In the new army horse-infirmaries, the superficial area has to be 127 square feet, and the cubic space 1,900 feet for each horse."

Captain Galton, in his book entitled *Healthy Dwellings*, says, "The great principle which ought to be kept in view in stables is to have the air moving freely through every part of them, above and around the horses when they are standing, and in all the angles between the floor and walls when the horses are lying down, and every horse should have sufficient ventilation for himself without being obliged to breathe the foul air of his neighbours. The condition would most completely be obtained in an open shed, such as is used for stabling horses in warm climates, and the

nearer we can approach to this construction, keeping in view the necessity for protecting horses in this climate, while at rest, from extreme cold and cold blasts of wind, the healthier will be the stable."

"That form of construction which affords the maximum facility for obtaining a free moving atmosphere throughout the body of the stable is the open roof with ridge ventilation carried all the way along."

Increased air space for each horse in the cavalry barracks, and the improved ventilation, reduce the mortality and improve the health of the horses to a marvellous extent. The great change for the better has been in France, noted by General Morin, who, in his work previously alluded to, states that Lieutenant-General Wathiez called attention to the fact that glanders was almost unknown in certain stables occupied in the field, while in others close by, where all the conditions as to food and exercise, etc., were exactly the same, and where the horses were better selected and looked after, they were rapidly decimated by this disease. There was nothing to account for it but the inferior ventilation, and this report caused an examination by M. Renault with the following result:

Average of loss on 1,000 horses.

	By Glanders.	By all other Diseases.
From 1835 to 1845 ...	51 ...	94
From 1846 to 1858 ...	21 ...	48

Ten years under the old system of stabling, twelve years with no difference except improved ventilation and larger air space for each horse! M. Renault, Inspector-General

of Veterinary Schools, etc., says, "the experiments were so satisfactory that a second course was begun, still keeping to the exact conditions previously enforced, except as to ventilation." The results were:

Average of loss per 1,000 *horses.*

	Glanders.	Other Diseases, including Glanders.
1846 (first year of the second period)	35	64
1847	26	58
1857	16	37
1858	10	28

On these results M. Renault says, "there can be no doubt as to the cause of this great and rapid improvement in the health of the horses. As before said, food, exercise, bedding, and everything else were kept exactly as before, except increased air space to each horse and improved general ventilation."

From 1858 to 1861, another great French veterinarian, M. Oger, being convinced of the importance of more and better air for the horses under his care, obtained permission to have all doors and windows open day and night, not only in the stables but in the infirmaries, and it was found that disease diminished and was cured so rapidly that the practice was adopted in other regiments with the result of improving the health generally and lowering the death-rate of the horses in the French army. This experience was confirmed by a series of government experiments, leaving no room for doubt as to the value of the largest supply of fresh air, and the

present system is based on the results of experiments so made and with this object in view.

General Morin also gives some interesting tables of amounts of air supplied to horses in the stables of the General Omnibus Company of Paris, on which he comes to the conclusion that each horse should have at least 50 cubic métres (1,400 cubic feet) of air space, and that a volume of 180 to 200 cubic métres per hour per horse should be provided to prevent the internal temperature from being raised more than 7 or 8 degrees above that of the air outside.

Farmers throughout the country have always sustained great loss from their wretched stables and cowhouse accommodátion, usually putting their stock into low close old buildings, in which it is impossible to keep them healthy. When it began to be understood that cattle required pure air and breathing space, the first improvement that suggested itself was to leave the roof of the buildings open to the slates. This was very well in summer for the limited time cattle would be indoors, but in winter, when they had to spend almost all their time in the sheds, the cold was almost as great a disadvantage as the former scanty accommodation.

Some non-conducting material, such as felt or rough lath and plaster ceiling on the spars, should be introduced, but it is important that there should be thorough ventilation with well arranged inlets and outlets.

Isaac Holden, Esq., of Oakworth, Yorkshire, has carried out at his stables much the same system of warming and ventilating as at his house. (See page 68.) The exhaust shaft forms an ornamental tower to the stables. The inlet for fresh air, and the outlet for vitiated air are so arranged that

no draughts are felt by the animals, and the air in the stables never seems to be tainted in the least.

Mr. Edward Holden, at his Model Farm, near Bingley, Yorkshire, has erected a large cowshed for his prize stock, in which he has carried out a system of both warming and ventilation. In severe winter weather he has no difficulty in maintaining the required temperature.

Those who have charge of cattle will find that as a matter of economy it is worth while in many cases to have some means of warming their stables and cattle sheds in winter.

In looking over the various plans we have given, suggestions will be found which will enable this to be done at moderate expense.

Ventilation can readily be managed by means of a lath and plaster duct or flue in the roof, with a cowl so arranged as to prevent any back-draught. There must always be an ample inlet of fresh air, with dampers to control the draught.

Damp Buildings and their Remedy.

The very idea of having to live within walls which are permeated with damp is chilling in itself, and yet many people who live in good-sized houses are subject to this, perhaps, for half the year, and at a season when it is likely to be most injurious to health. The following table from *Notes on Building-Construction*, published under the auspices of the Science and Art Department, South Kensington, 1879, shows the absorbing capacity of various kinds of bricks :

Absorption of Water by Brick.— Table.

Description of Brick.	Weight when Dry. lbs.	oz.		Percentage of Water absorbed.
Malm Cutters	4	15	...	22
Malm Best Seconds	5	1½	...	20
Malm Brown Facing Paviors	5	0½	...	17
Malm Hard Paviors	4	13	...	9½
Washed Bright Yellow Fronts	5	1	...	20
Malm Shippers	5	1¼	...	8⅓
Malm Bright Stocks	4	13½	...	22
Washed do.	5	0½	...	16
Common Shippers	5	0½	...	9
Common Grey Stocks	5	0	...	10½
Do. Hard do.	5	0½	...	7½
Malm Grizzles	4	13½	...	22
Do. Place	5	0½	...	21
Common do.	5	0½	...	20
Washed Shippers	5	2	...	10
Do. Hard Stocks	4	15½	...	4¼
Do. Grizzle	5	0	...	21
Common do.	5	1	...	18
Washed Place	5	0	...	21
Staffordshire Dressed Blue	9	5	...	2·3
Do. Pressed do.	8	11	...	3·7
Do. Common do.	9	0	...	6.5
Do. Bastard	9	8	...	11·8
Machine Made, Red	9	14	...	9·9
Do. from Leeds	10	0	...	10·0
Wire Cut White Gault	6	3	...	19·0
Pressed Gault	5	12	...	19·5
Brown Glazed Brick	8	6	...	8·6

Absorption of Water by Stone.—Table.

Nature of Stone.	Bulk of Water absorbed as compared with bulk of Stone per cent.	Authority.
Several specimens of good Granite and Syenite	½ per cent. ...	W
Do. do. indifferent specimens	1 per cent. ...	W
Do. do. very bad...	3 per cent. ...	W
Trap and Basalt	A trace. ...	W
Do. do.	$\frac{1}{10}$ to $\frac{1}{5}$ per cent. ...	
SANDSTONES.		
Craigleith. Very durable	8 per cent. ...	C
Park Spring do.	8 per cent. ...	C
Giffneuk. Moderately durable ...	10 per cent. ...	C
Heddon. Do.	10·4 per cent. ...	C
Kenton. Do. ...	9·9 per cent. ...	C
Mansfield. Do. ...	10·4 per cent. ...	C
Hassock. Very bad	20·0 per cent. ...	W
LIMESTONES.		
Marble	A trace.	
Portland. Very durable	13·5 per cent. ...	C
Ancaster. Durable	16·6 per cent. ...	C
Bath (Boxground).....................	17 per cent. ...	C
Ketton. Durable	15·1 per cent. ...	
Chilmark	8·6 per cent. ...	C
Roch Abbey. Durable	17·2 per cent. ...	C
Kent Rag. Do.	1⅓ per cent. ...	W
Ransome's Stone (artificial)	12 per cent. ...	W
Victoria do. do.	7·6 per cent. ...	W
Apœnite do. do.	12 per cent. ...	W

W. Deduced from experiments detailed in Wray, *On Stone.*
C. Royal Commission on Stone for Houses of Parliament.

These tables show what a great quantity of water may be absorbed and retained in walls.

Captain Douglas Galton, in his new work, "*Healthy Dwellings,*" says : "In this climate damp walls, besides being unhealthy, are uneconomical. They cause a great absorption of heat by evaporation of moisture from the surface. New walls are always damp. The quantity of water which will be contained in a new wall is very remarkable. Suppose that 100,000 bricks are used for a building, each weighing seven pounds, a good brick can suck up from 10 to 20 per cent. of its weight in water, but assume 7 per cent. as what gets into it by the manipulation of the bricklayer. Also assume that the same amount of water is contained in the mortar, a quantity certainly much under stated ; the mortar forms about one-fifth of the walls ; thus nearly 100,000 pounds of water, equal to 10,000 gallons, may be assumed to be put in the walls in the process of building, and which must be removed from the walls of the house before it becomes habitable. This water must be removed by evaporation into and by the air. The capacity of the air for removing water depends upon the different tension of the vapour at different temperatures, on the quantity of water already contained in the air as it flows over this moist surface, and finally on the velocity of that air. Assuming the average temperature of the year to be about 50° Fahrenheit, and an average of the hygrometric condition of the air to be 75 per cent. of its full saturation, at the temperature named, one cubic foot of air can take up four grains of water in the shape of vapour, but as it contains already 75 per cent. of these four grains, which amounts to three grains, it can only take up one additional grain. As often then as

one grain is contained in the 10,000 gallons of water mentioned above, as many cubic feet of air must come in contact with the new walls, and become saturated with the water contained; or, about 700,000,000 cubic feet of air are required to dry the building in question. Therefore the drying of a building will be best effected by passing a large volume of air through it, and air at a higher temperature, and therefore of a greater hygrometric capacity than the outer air, will effect this object most rapidly."

Every large new house ought to be fitted with a good air warmer, which would dry the walls thoroughly before it is inhabited; if some artificial means is not employed the drying is very slow and doubtful. There are many places of worship where the walls are full of moisture, notwithstanding that they are provided with hot-water pipes for warming, but are usually without adequate provision for ventilation.

The most remarkable instance of this kind we have met with is Holy Trinity Church, Stretford Road, Manchester. This church was fitted with a very good hot-water arrangement, with a substantial and powerful saddle boiler, and yet the walls were always wet. At last the boiler and pipes were removed, and a large-sized Convoluted Stove was substituted. The fixing of this apparatus was finished on a Thursday evening, and a slow fire was then started. On Friday morning it was fired briskly, and the result was that the water which had never dried out of the walls during the many years the church had been built, ran down in streams, keeping two women constantly employed with mops for two days, and on Sunday morning there was so much steam about the organ that it could not be used for the morning service.

The walls first began to dry at the top, and by continuous firing until the Monday they were all perfectly dry, and have been so ever since. The case of the Church of St. Andrew's, Westminster, was very similar.

Our most recent experience has been at the house of a Wesleyan minister at Oxenhope, near Keighley, Yorkshire, where the walls were so damp that the health of the whole family suffered. A small Convoluted Stove was fixed, which in a few days dried the house thoroughly.

Extract from Letter referring to the latter house:—"Respecting the damp coming out of the walls, they were very bad; the paper to all appearance would fall off, but in all the rooms, except one, and that only a little, the damp has disappeared, not leaving any trace on the paper, and on the wall where the paper is not yet dry I do not think the paper will fall off."

In cold weather this circulation or movement of air can hardly be maintained without a heating apparatus. By fixing a properly constructed air warmer in the basement, warm air can be delivered in several rooms and into the hall so as to ascend the staircase to the bedrooms, and maintain an equable temperature day and night. This can be done with less than the fuel and attention required for one open fire.

All buildings ought to have near or at the ground level a course of asphalt, or other non-conducting material, to prevent damp ascending the walls from the ground. Where there is no ventilation or regular circulation of air, walls will not remain dry when the atmosphere is very humid, from the capillary rising of wet.

Fogs.

Fogs in large towns are now occupying the earnest attention of scientific men. In a very able paper by Dr. Alfred Carpenter, read at a meeting of the Society of Arts, December 8th, 1880, speaking of London fogs, he says: "I have committed myself to the theory that it is smoke caused by the destructive distillation of coal and other fuel which causes the greater part of our evil, and it is not a radiation fog, or a 'Scotch mist,' or simply a mist from the bosom of Father Thames, or the Essex Marshes, or the London clay. . . . . The method now used for warming our houses and cooking our food is wasteful in the extreme, and five-sixths at least of the developed heat is lost and much of the fuel passes away unconsumed."

In the after discussion on Dr. Carpenter's paper, Sir Francis Knowles, F.R.S., said: "This was a most important subject, affecting not only the pockets of the people, but their health and the length of their lives. He wished to support, as far as possible, the conclusions to which Dr. Carpenter had arrived. An ordinary coal fire was generally left to burn rather low, then the door was opened, letting in a fierce current of cold air, and the housemaid piled on a heap of coal, which left all the inmates of the room in the discomfort of a glacial period until it burned up. He had made some calculations as to the result of the coal consumption in London, which were as follows: The annual consumption might be taken at about 8,000,000 tons, or a daily consumption of 22,000. The ammoniacal liquor from bituminous coal was about 179lbs. per ton, and deducting 13lbs. for ammonia, it left about 166lbs. of watery vapour per ton of coal, or 16½ gallons. In other words,

there were 3,942,400lbs. of ammoniacal liquor daily ejected into the atmosphere, with a due accompaniment of coal-tar and blacks. The injurious influence of this on the respiratory organs needed no proof, but prize cattle had been known to suffer under its influence. Turned into cubic feet, the watery vapour of this liquor amounted to 533,280, or 51,194,880 square feet, one-eighth inch in thickness, representing a most respectable daily rainfall. If that computation did not show what was the cause of fogs, he did not think anything would. The waste of this ammoniacal liquor was most serious. Our coal fields contained an enormous supply of nitrogenous matter, which, properly applied, would convert the whole of England into a garden; and from a calculation he had made, he estimated that the ammonia evolved from the combustion of coal in London alone was equal to the production of six million quarters of corn. Extending that to the whole country, would give some idea of the effect of this waste on our agricultural prosperity. Some time ago he tried an experiment with carburetted hydrogen from peat on red hematite ore, and, at the end of one hour and a quarter, when he drew the charge from the retort, he found mere charcoal at one side, and on the other the carburetted hydrogen had reduced the hematite almost to the condition of a metallic sponge. This showed how advantageous it would be partially to coke the coal, employing the gas in this way, before sending it to London for use in fire-places. There were two modes of avoiding the evil of fog, viz., using anhydrous coal, or anhydrous gas. In any smoke-consuming apparatus which might be devised, he would suggest, lastly, that it would be desirable to provide some means for condensing and utilising the ammonia."

Dr. R. Angus Smith's analysis of the air shows the following results:

"Oxygen of the air in wet and in dry foggy weather. Continuing the subject and going further into detail. In very wet weather in Manchester, and still before the laboratory, the following results were obtained:

	Oxygen.
	20·90
	21·01
	21·01
	21·05
	20·96
	104·93
Average	20·98

In dry, foggy, and frosty weather, when the smoke of Manchester had little exit from the town, the results were:

		Average Impurity.
Near centre of town		20·90
		20·88
At Laboratory		20·90
		20·96
At Laboratory,	Afternoon	20·91
" "	Forenoon	21·01
" "	Afternoon	20·82
		146·38
	Average	20·91

20·82 and 20·89 were found in a dense fog, such as has rarely visited Manchester. The eyes began to smart, and in walking on the pavement carters were leading their

horses into shops in the day-time—we can scarcely say in the day-light."

"Thus we have certified by experiment, as well as the testimony of the senses, the inferiority of the air at certain times, and these senses seem to estimate on certain occasions an amount as small as 0·07; but they do not estimate the loss of oxygen, only the corresponding increase of impurities."

The tens of thousands of black fountains from the chimneys is no doubt the cause of the blackness and yellowness of fogs in large towns, but not the sole cause In the *Manchester City News*, December 24th, 1880, the following short sensible article appeared.

"WHAT IS FOG?—The popular impression appears to be that fog is smoke, and that the furnaces and fire-places which create smoke are the creators of fog, and that for all the ills and discomforts that flow from fogs the smoke and its causes are responsible. We may well question the exactness of this reasoning, or, perhaps, assumption. Fog is a terrible nuisance in a large town, and especially so in the metropolis. What evils it possesses are there, because of the surroundings, greatly intensified; but fogs are not the property or privilege of the town—not even of the metropolis alone—and those who have to endure their thick gloom in the rural districts can tell of a thickness that is almost suffocating and of a darkness that can almost be felt. Smoke may intensify fog, but smoke alone cannot create fog; if it did, whence come the terrible and most dangerous fogs that afflict the ocean and render at certain times the English Channel so dangerous? We get tremendous fogs in districts remote from masses of smoke generators when

the forces that generate fog are in operation; and no doubt wherever there is most moisture, either in or on the earth, there will the aqueous vapour be most dense and troublesome. London may be finely drained, but it lies in a valley; and from the Thames are ever arising the exhalations that produce fog. Equally where streams and rivers run there is the greatest amount of vapour. It may be easier to explain the cause of fog than tell how to get rid of it; but probably it will be found that smoke has no more to do with its formation than it has with wet cycles or excessive frost."

As to the unnecessary black smoke, the result of imperfect combustion, and the consequent waste of fuel, all are agreed, and that it is the duty of the authorities and of everyone with any influence to do all that is possible to lessen the evil. It is not only a question of economy but of health. No one who has not had some experience of the black fog of large towns can form any conception of its effects, leaving everything besmeared with soot.

The smoke nuisance is greatest in those districts where fuel is cheapest, and most of the busy manufacturing towns of the north send up a dense mass of black smoke, which, in certain conditions of the atmosphere, hangs overhead like a funeral pall. Fuel is wasted in the dwelling houses, workshops, large manufactories, and everywhere where fires are used.

Sheffield, as might be expected, is notorious for the amount of black smoke it produces. In the course of a lecture on "Fuel," at Firth College, before the Sheffield Literary and Philosophical Society, Mr. A. H. Allen took occasion to mention that about 60 tons of soot were sent

into the air daily by the chimneys of Sheffield. He thinks the way to avoid smoke is to burn the solid and gaseous constituents of fuel separately. Calculations have been made that if all the coal used in London were partially carbonised by the gas companies, both they and the public would reap an advantage. The companies would obtain a larger quantity of by-products, and still leave the coal with sufficient "gas" in it to ignite quickly.

The open fire-place contributes greatly to the black smoke of large towns, as the combustion in ordinary grates is very incomplete, and in some large buildings, such as hotels, there are open fire-places in almost every room, whereas the whole building could be easily warmed with one or two coke fires in the basement with almost no smoke. The largest hotels in America are thoroughly warmed in this manner and without difficulty.

If the fog nuisance leads to serious consideration of the subject, with a practical result in material diminution of the quantity of black smoke, we shall have reason to be thankful.

A Scheme for Abolishing Fog.

"Amongst the private bills deposited for the ensuing session of Parliament is one of a somewhat novel description, its leading provision being the abolition of smoke, fogs, and impure air in large towns. For some time past Captain Douglas Galton, C.B., F.R.S., Mr. Le Fevre, C.E., and other engineers, have been taking observations as to the altitude of fogs and smoke over London. The result proves that at a height equal to the Victoria Tower or the dome of St. Paul's, owing to the moisture of the upper atmospheric

strata, the air over the metropolis is particularly free from impurities. The bill proposes, by means of a pipe fixed to the highest part of our principal buildings, and with the aid of a fan to bring down the pure air from above and force it into buildings such as St. Paul's and the Houses of Parliament, thus displacing the fogs and smoke and all impure air. At the same time by passing this pure air through a heated chamber the buildings can be warmed."—*London Morning Papers.*

CHAPTER III.

Air Warmers, Boilers, &c.

DURING the present century the progress made in air warmers has been very small, while ingenuity has been very active in the construction and improvement of apparatus for heating water and generating steam. The necessity for a powerful boiler for locomotive engines first stimulated invention in this direction.

Dr. Smiles, in his "*Life of George and Robert Stephenson*," says: "As early as 1803, Mr. Woolf patented a tubular boiler, which was extensively employed at the Cornish mines, and was found greatly to facilitate the production of steam, by *the extension of the heating surface.* The ingenious Trevithick, in his patent of 1815, seems also to have entertained the idea of employing a boiler constructed of 'small perpendicular tubes,' with the same object of increasing the heating surface. These tubes were to be closed at the bottom, and open into a common reservoir, from which they were to receive their water, and where the steam of all the tubes was to be united.

"About the same time George Stephenson was trying the effect of introducing small tubes in the boilers of his locomotives, with the object of increasing their evaporating power. Thus, in 1820, he sent to France two engines, constructed at the Newcastle works, for the Lyons and St. Etienne Railway, in the boilers of which tubes were placed containing water. The heating surface was thus found to

be materially increased, but the expedient was not successful, for the tubes, becoming furred with deposit, shortly burned out and were removed. It was then M. Séquin, the engineer of the railway, nursing the same idea, adopted his plan of employing horizontal tubes through which the heated water passed in streamlets. Mr. Henry Booth, the secretary of the Liverpool and Manchester Railway, without any knowledge of M. Séquin's proceedings, next devised his plan of a tubular boiler, which he brought under the notice of Mr. Stephenson, who at once adopted it, and settled the mode in which the firebox and tubes were to be arranged and connected. This plan was adopted in the construction of the celebrated 'Rocket' engine, the building of which was immediately proceeded with at the Newcastle works.

"The principal circumstances connected with the construction of the 'Rocket,' as described by Robert Stephenson to the author, may be briefly stated. The tubular principle was adopted in a more complete manner than had yet been attempted. Twenty-five copper tubes, each three inches in diameter, extended from one end of the boiler to the other, the heated air passing through them on its way to the chimney; and the tubes being surrounded by the water of the boiler, it will be obvious that a large extension of the *heating surface* was thus secured. The principal difficulty was in fitting the copper tubes within the boiler so as to prevent leakage. They were made by a Newcastle coppersmith, and soldered to brass screws which were screwed into the boiler ends, standing out in great knobs. When the tubes were thus fitted, and the boiler was filled with water, hydraulic pressure was applied; but the water squirted out at every joint, and the factory floor was soon flooded.

Robert went home in despair, and in the first moment of grief, he wrote to his father that the whole thing was a failure. By return of post, came a letter from his father, telling him that despair was not to be thought of, that he must 'try again'; and he suggested a mode of overcoming the difficulty, which his son had already anticipated and proceeded to adopt. It was, to bore clean holes in the boiler ends, fit in the smooth copper tubes as tightly as possible, solder up, and then raise the steam. This plan succeeded perfectly, the expansion of the copper tubes completed a water-tight boiler, capable of withstanding extreme internal pressure."

The experiments and results recorded by Dr. Smiles form the basis of all the improvements which have been made since then, both in steam and circulating boilers. Tubular boilers and coils have been used in every variety of form, the object always being to gain heating surface. One of the best tubular boilers we have seen was made specially for warming the extensive vineries, greenhouses, and winter gardens at Oakworth House, Keighley, Yorkshire; it has been in use there several years, but has not been adopted by any boiler maker and brought before the public.

With recent improvements in working malleable iron, welded and rivetted boilers for the circulation of water have been brought to great perfection. We illustrate some of the best forms from the catalogue of Messrs. R. Jenkins and Co. of Rotherham. An inspection of these will show the ingenuity displayed in gaining the utmost possible heating surface without any joint in the metal; they are substantial and durable. It will be noticed that they give

with their price list a table of the heating power of the various kinds and sizes of boilers. This is most valuable for comparison with other makes. We give only one table, but Messrs. Jenkins will no doubt be glad to supply any further information.

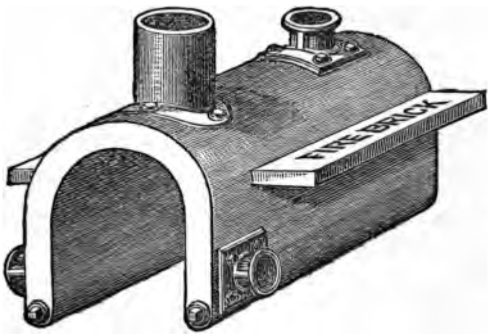


Fig. 29.— ELEVATION.

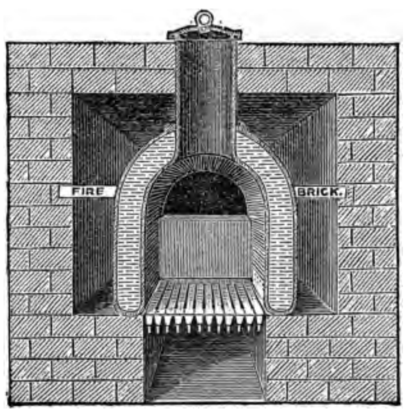


Fig. 30. — SECTION IN BRICKWORK.

THE "WENTWORTH" BOILER.—This boiler has the combined advantages of the well-known saddle form and (having the top feed) it is as easily fed as the vertical tubular boiler; it is made with water way midfeathers or plate iron solid

midfeathers as desired. The fire is completely surrounded by the boiler, by this means the fuel is economised, and the circulation of the water improved.

Boilers with Solid Plate Iron Midfeathers.

No.		Size of Boiler. Long Inside Arch. W. H.		Outside Measure.		Estim'd Heating P. 4in P.
		In. In. In.		In. In.		Feet.
1	...	20 × 14 × 14	...	19 × 16½	...	500
2	...	24 × 16 × 16	...	21 × 18½	...	700
3	...	30 × 16 × 16	...	21 × 18½	...	900
4	...	30 × 18 × 18	...	23 × 20½	...	1000
5	...	36 × 16 × 16	...	21 × 18½	...	1000
6	...	36 × 18 × 18	...	24 × 21	...	1100
7	...	42 × 18 × 18	...	24 × 21	...	1300
8	...	42 × 22 × 20	...	28 × 23	...	1400
9	...	48 × 22 × 20	...	28 × 23	...	1650
10	...	54 × 24 × 24	...	30 × 27	...	1900
11	...	60 × 24 × 28	...	30 × 31	...	2400

Boilers with Water Way Midfeathers.

No.		Size of Boiler. Long Inside Arch. W. H.		Outside Measure.		Estim'd Heating P. 4in P.
		In. In. In.		In. In.		Feet.
12	...	20 × 14 × 14	...	19 × 16½	...	550
13	...	24 × 16 × 16	...	21 × 18½	...	800
14	...	30 × 16 × 16	...	21 × 18½	...	1000
15	...	30 × 18 × 18	...	23 × 20½	...	1150
16	...	36 × 16 × 16	...	21 × 18½	...	1200
17	...	36 × 18 × 18	...	24 × 21	...	1300
18	...	42 × 18 × 18	...	24 × 21	...	1500
19	...	42 × 22 × 20	...	28 × 23	...	1650
20	...	48 × 22 × 20	...	28 × 23	...	1900
21	...	54 × 24 × 24	...	30 × 27	...	2200
22	...	60 × 24 × 28	...	30 × 31	...	2700

SADDLE BOILER, No. 61, WITH TERMINAL WATER WAY END AND RETURN FLUE THROUGH TOP. — This Boiler has now been before the public over twelve years, and it is still considered, for moderate lengths of pipe, to be the cheapest and most easily managed Boiler of the Saddle pattern.

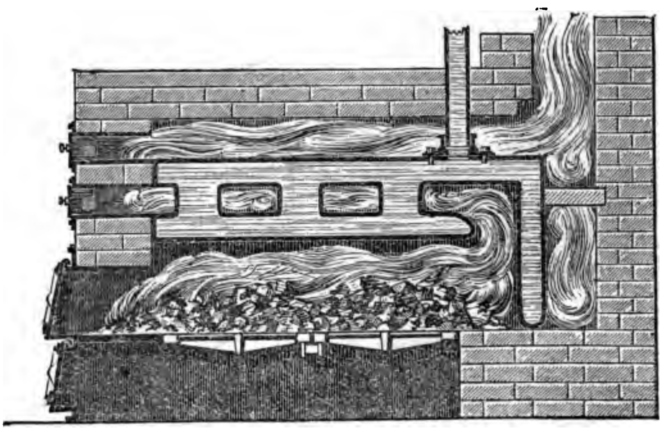


Fig. 31. — SECTION IN BRICKWORK.

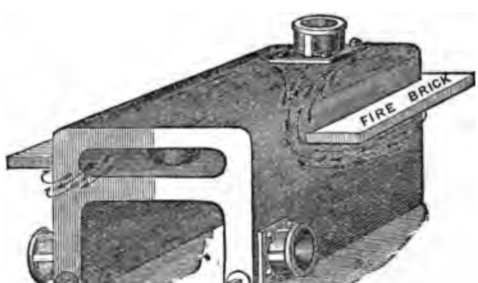


Fig. 32. — ELEVATION.

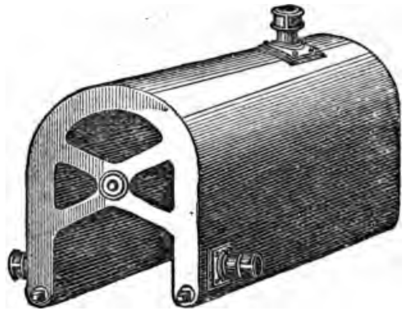


Fig. 34. — ELEVATION.

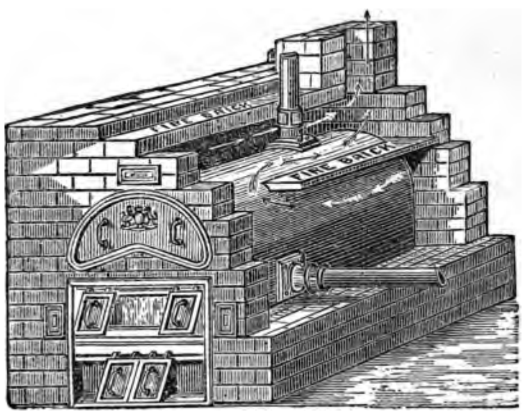


Fig. 35. — ELEVATION IN BRICKWORK.

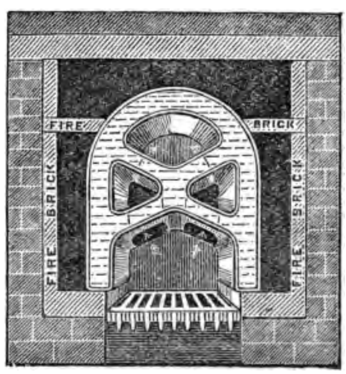


Fig. 36. — SECTION IN BRICKWORK.

THE "EXPRESS" BOILER:—This is a modification of and an improvement upon the Daddle Boiler, the flame returning to the chimney through the side flues, and not along the outside, as in the Saddle Boiler; by this means the cost of brickwork is diminished, and all the heat is absorbed by the boiler, instead of spending itself upon brick flues.

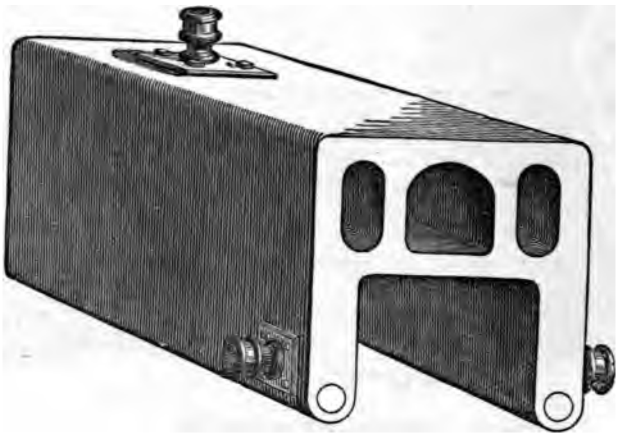


Fig. 33. — ELEVATION.

"CRUCIFORM SADDLE" BOILER, WITH TERMINAL WATER WAY END AND RETURN FLUES THROUGH CROWN.—This is another form of Terminal End Return Flue Boiler, its chief advantage is that there are no horizontal surfaces over the fire, for the possible lodgement of any sediment, and the consequent incrustation which (with the water of some districts) is of frequent occurrence.

The flame and heat passes from the fire into the two triangular side flues, and then into the large upper flue, which conveys it to the back of the boiler, whence it may be conducted round the outside by means of brick flues, or direct to the chimney, as may be desired.

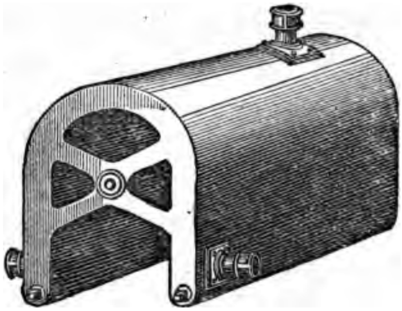


Fig. 34. — ELEVATION.

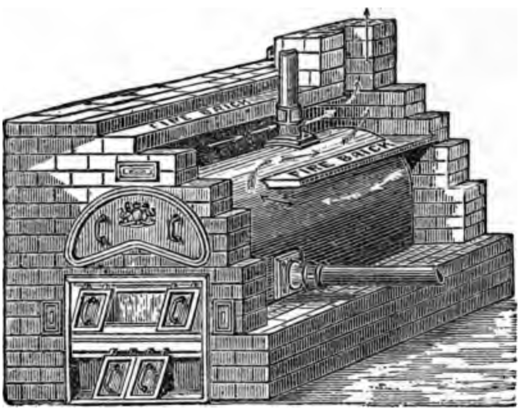


Fig. 35. — ELEVATION IN BRICKWORK.

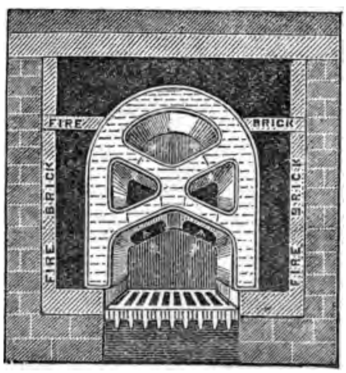


Fig. 36. — SECTION IN BRICKWORK.

"DUPLEX CYLINDER" BOILER.—This Boiler was first introduced in 1876, and every year its good qualities becoming more known, increased numbers are being sold. It is simple in construction, and fuel may be put on either at top or bottom: when banked up from the top it will go from 18 to 24 hours without attention. The side flues carry off the flames and heated gases, while the centre one contains the reserve of fuel. The inner cylinder gives this a very largely increased power over other Cylinder Boilers, as three internal heating surfaces are exposed to the direct action of the flames.

Fig. 37.

Fig. 38.

The two plates (Figs. 37, 38) give another view of this useful boiler.

The intense cold weather of the winter just past has proved the advantage of boilers for greenhouses, which are fed at the top and hold a large amount of fuel, in which case the fire remains good through the night, there being no difficulty in keeping the pipes at the necessary heat for preserving plants.

If the fire space is too limited, the fire must be attended to during the night (not a very agreeable occupation when

the thermometer is below zero.) Of late years the makers of boilers, pipes, bends, and other fittings for the circulating system, have exercised considerable ingenuity in providing everything necessary for reducing or enlarging the flow pipes, turning corners, dipping or ascending, so that the execution of this class of work has been greatly simplified, and now almost any respectable plumber can do hot water fitting, and they all know that one foot of four-inch pipe warms 100 feet of air; there is, therefore, no necessity for giving elaborate tables, as was the custom in works written twenty years ago. Another simple rule should never be lost sight of, that is, always have a good margin of heating power both in boiler and pipes.

The High Pressure Hot Water Circulating System.

The boiler used in this system consists of a coil of pipes of small bore, built in brickwork or in an iron case. The pipes for circulation are also of small bore. The coil (A) and pipes are filled with water and are then hermetically sealed. From the constant circulation and reheating of the same water the pipes become very hot. This arrangement necessitates an expansion pipe (B), which must be fixed at the highest level, and be of capacity equal to one-twelfth of the whole of the circulating pipes, otherwise an explosion would be inevitable. Fig. 39 shows the system as applied to a three story building.

When the high-pressure system was first introduced for warming buildings, many fires occurred in consequence of the hot pipes (which frequently attain a temperature of

600° to 700°) not being kept sufficient distance from timber and other inflammable material. The Manchester Assu-

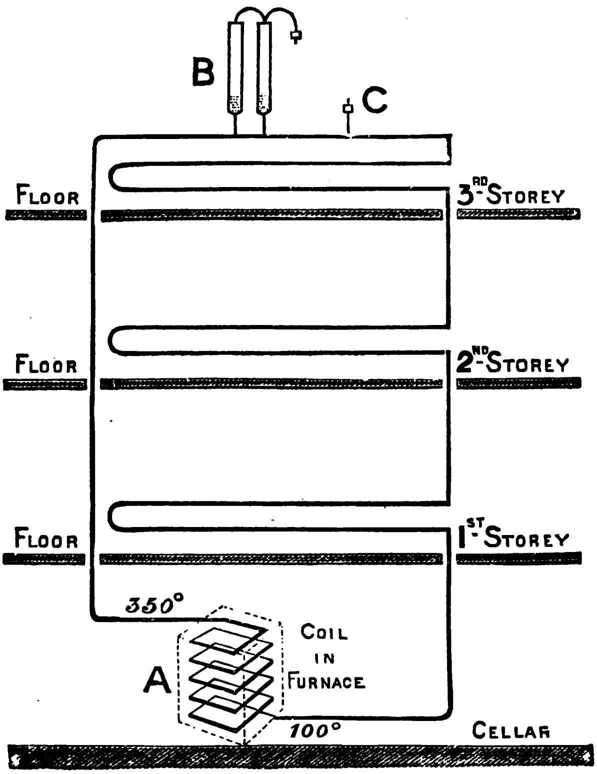


Fig. 39. — HIGH PRESSURE CIRCULATION.

rance Office appointed a sub-committee to enquire into the matter, and the following abridged report gives the result of their investigation:

"I. First class of experiments, viz., those made with the whole length.

1. The pipe from the furnace became very soon sufficiently hot to singe and destroy small feathers resting upon it.

2. Speedily afterwards, the same pipe exploded gunpowder.
3. On the highest pipe, within a foot of the expansion pipe, bismuth was readily melted, denoting a temperature of 470°.
4. Feathers singed instantly, and matches lighted at the same place.
5. Gunpowder inflamed readily in various parts of the flow pipe and on the expansion pipe.
6. Blocks of wood, of five different species, were charred; from the deal wood the turpentine issued profusely.
7. Other combustible materials were also severally much charred.

"II. Class of experiments with the shorter circulation. By this change a greater pressure was immediately observable, as the expansion pipe and several of the joints emitted steam and admitted the escape of water.

1. Cane shavings on the pipe above the furnace readily inflamed.
2. Lead melted at the same place; and the temperature must therefore, have exceeded 612°.
3. Different wood shavings inflamed on the upper pipe.
4. Cotton ignited freely at the same place.
5. Matting inflamed at the same place.
6. Cotton, hemp, and flocculent matter, collected from Mr. Schunck's fustian room, ignited on the returning vertical pipe.
7. The blocks of wood, tied to different parts of the tube, were much acted upon, and charred in a very short time.

"Observing the expansion pipe to be in a state of con-

siderable agitation, and warned of an explosion, the temperature was reduced, and the experiments were, for a time, suspended.

"The pipes having, before three o'clock, been refilled and screwed up, for the express purpose of an explosion, the following experiments were made in the progress of the preparation :

1. Mungeet was readily ignited.
2. Different sorts of paper and pack thread were destroyed.
3. Bismuth fused instantly.
4. Cotton inflamed.
5. Sheep's wool became speedily charred.
6. At five o'clock the sheet-lead, affixed to the upright pipe, freely melted ; steam issued violently from the bend in one of the upper horizontal pipes, and in three minutes afterwards the explosion occurred in the furnace pipe, at the top of the seventh coil, which presented, on subsequent examination, a lateral aperture about two inches long and about one-sixteenth of an inch broad.

"On the lapse of two or three minutes after the commencement of the explosion, the furnace was entirely emptied of its contents, which were propelled, in a divergent direction, like one mass of fire, so as almost to fill the apartment. The force with which the ignited ember rebounded from the opposite wall, and other obstructions, occasioned them to scatter in profusion, like a shower of fire, over every part of the place. The noise was so great as to bring to the spot a multitude of people from the adjoining streets. A number of articles in the shop, as for example, packing

cloth, paper, and hemp, were subsequently found to be on fire in different parts of the premises.

"These appearances, and their immediate effects, seem to have been precisely similar to those which are said to have been witnessed at the explosion in the warehouse of Messrs. Crafts and Stell, and would evidently have been adequate, in the same situation, to produce all the consequences.

"It may here be observed that the experiments clearly prove that the heat in different parts of the pipe is not uniform. Generally, it is greatest at the highest elevation, where its superior temperature appears to be of the longest duration under ordinary incidental changes. At the commencement of the operation, however, and a short time after fresh fuel had been applied, the temperature was highest in the flow-pipe contiguous to the furnace.

"Another circumstance, likely to produce an inequality of heat, may be adverted to: the tubes are far from being of uniform internal diameter; the consequence of which must be, that as the same quantity of water has to pass, in the same time, through every part of the apparatus, the liquid must move with greater velocity at one place than at another, and thus, from obvious causes, develope a greater quantity of caloric. The difference is sometimes so great in the relative bores of the tubes employed, that in some which were examined, one tube had an internal diameter of $\frac{9}{16}$ and another $\frac{3}{4}$ of an inch, that is to say, in the ratio of 3 to 4; or taking the relative areas or sections of the tubes, which represent the relative quantities of fluids contained in a given length, in the proportion of 9 to 16. Thus, taking the velocity reciprocally as the section of the pipe,

the velocity of the water at one part of the apparatus being represented by 16 feet, the velocity in another part would be 9, or the rapidity of the current would be at one place nearly double that which it was at another.

"It is stated in a work recommending the Hot Water system, that 'the application of heat fills the ascending or flow-pipe with minute bubbles of steam, which rise rapidly to the upper part of the tube, and become there condensed into water again.' Now, as condensed steam, wherever it occurs, produces about seven times as much heat as the same quantity of water at the same temperature, we have, at once, a reason for the heat of the pipe being generally greater at a distance from the furnace than contiguous to it. This apparent anomaly, which has repeatedly been observed and denied, admits therefore of every explanation."

"Signed,

"JOHN DAVIS,
Lecturer on Chemistry, &c.

"GEORGE VARDON RYDER,
Surveyor to the Manchester Assurance Co.

"10th March, 1841."

The report, though abridged, is somewhat lengthy, but the subject is important, and the facts apply with as much force now as when the experiments were made. We have no doubt those experiments and this report had a wholesome effect upon those who were engaged in the execution of this class of work, and have been the means of preventing many fires.

At page 81, it will be seen that the temperature of hot air entering a Turkish bath is never higher than 312°, the

flues are brick and mortar, or concrete, and no timber is allowed near them. If this is necessary for safety, pipes which attain to a temperature of 600 or 700° ought certainly to be kept clear of timber and all inflammable material.

Air Warmers, Stoves, &c.

The Roman Hypocaust was the first attempt at economical warming apart from the open fire-place, and was the parent of the earliest modern hot-air system, which consisted of a series of brick flues underneath the floor, with grids at intervals to give off the heat. This may still occasionally be seen in old churches. Formerly it was much used for warming greenhouses. This system has been almost entirely abandoned, from the constant liability of the joints of the flues to open and allow smoke and sulphur to escape into the building; from bad draughts, in consequence of the distance the smoke has to travel; and from the danger of the over-heated flues igniting the timber of the floor. Many buildings have been destroyed by fire through this mode of heating.

The first improvement was the adoption of the Metal Stove as an underground air-warmer. That known as the "Cockle" has been most in favour, and is still in use even in its most primitive form. In shape it may be either square, round, or dome-shaped; but the latter withstands the action of the fire best, being usually made of cast-iron. Notwithstanding the antiquity of this stove, it has been several times put forth, and even patented as a new invention.

Though the "Cockle" was an improvement on the flue system, there being less danger of fire, still the extent of

its heating and radiating surface was far too small to warm *large* buildings efficiently. To increase the heating surface some makers connected two "Cockle" stoves side by side, the smoke and flame passing from one to the other.

For a long time after the introduction of the "Cockle" there was no important improvement made until the "Gill" stove was introduced. It will be seen from Figs. 40, 41, 42. and section, that the surface gained is mostly external; for one foot of internal there are ten feet of external surface; it is therefore not a very powerful air warmer, and is now chiefly used as an ornamental stove for entrance halls, &c.

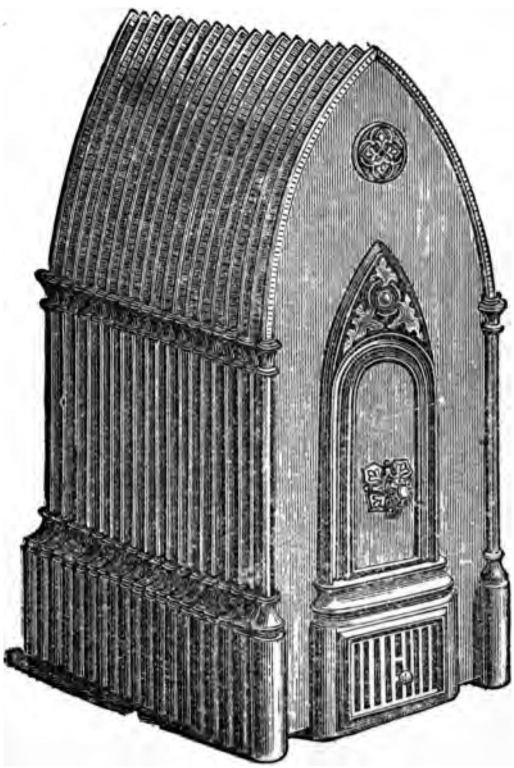


Fig. 40. — ELEVATION OF "GILL" STOVE.

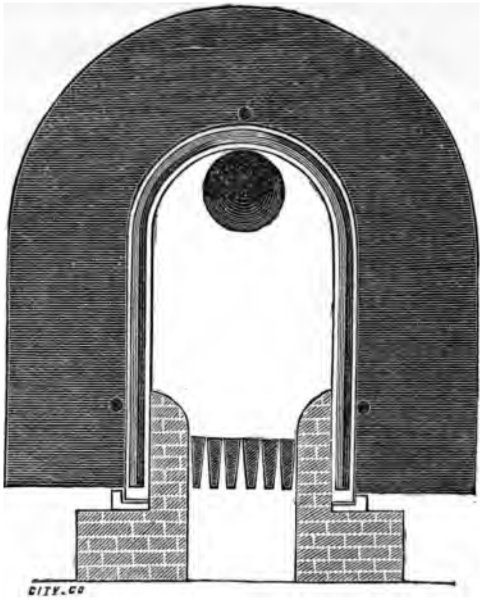


Fig. 41. — TRANSVERSE SECTION.

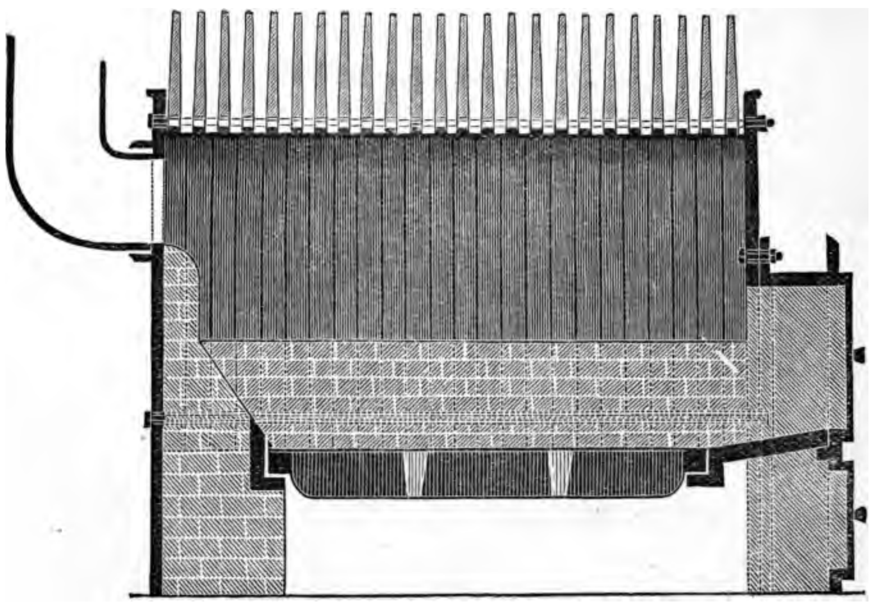


Fig. 42. — LONGITUDINAL SECTION. "GILL" STOVE.

The "Gurney" stove is simply a variation of the "Gill" stove. In 1858 we examined this stove with a view to adopting it for heating Turkish baths, but came to the conclusion that it was not sufficiently powerful for that purpose.

There being no stove of sufficient power for heating Turkish baths, we adopted a series of pipes for that purpose, see Fig. 43. This heating apparatus answered very well indeed, and for a short time it gave plenty of heat, and a large volume of air was passed into the rooms, so that

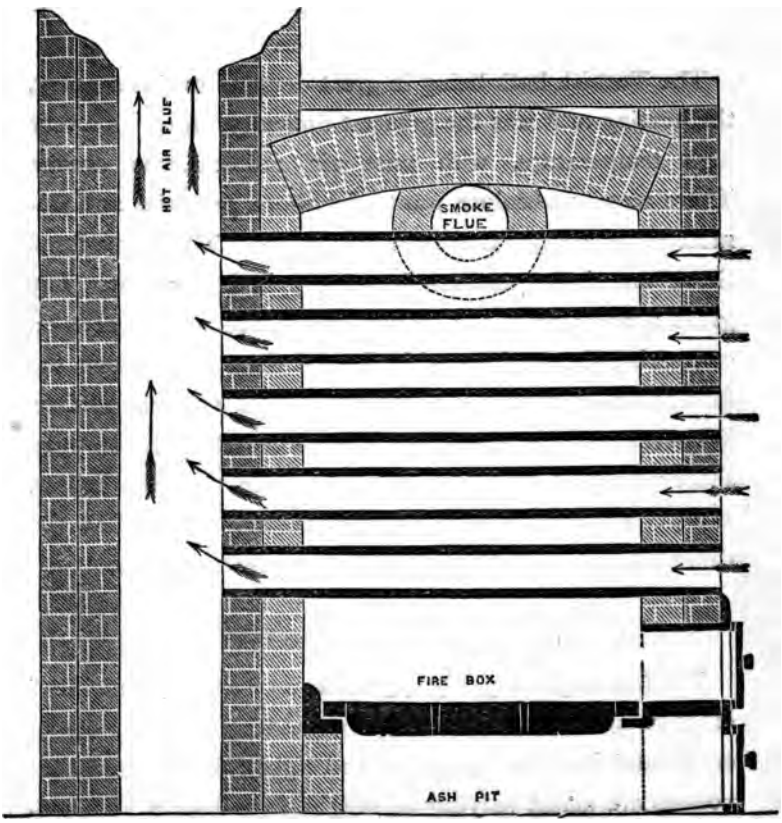


Fig. 43.—SECTION OF TUBULAR APPARATUS.

ample ventilation was secured. The drawback was the frequent burning out of the pipes. Several firms are still using tiers of pipes in this way for heating purposes, both in the horizontal and perpendicular form, but they must ultimately be abandoned, as with a strong smoke draught they may be burnt out in a few days. After discarding the pipe stove for heating Turkish baths, we adopted the dome-shape "Cockle" as being the most durable, and to gain additional heating surface carried a cast-iron smoke pipe through the hot rooms. The burning out of this stove was not nearly so rapid as with the pipes, and yet it had to be renewed in a comparatively short time.

The Turkish bath being in great demand in this country, the heating of it was the greatest difficulty, requiring a very high temperature, with pure air and *constant change.* There was an absolute want of a more powerful and durable heating apparatus than any in use. The Convoluted Stove was then constructed and supplied the want. The great advantage of the Convoluted Stove will be seen on comparing the sections with that of the "Gill" stove, the former having nearly as much internal as external surface. Whoever was the inventor of the "Gill" stove he stopped short with half the ideà. Had he made the gills hollow, and put a smoke box on the top, he would have had the Convoluted Stove, which has been so great a success.

Description of the Convoluted Stove.

The first engraving, Fig. 44, shows an "Eight Convolute" stove complete. A stove may be made of any number of convolutes from five to twelve, and eight different sized convolutes are made, varying in weight from half a hundred-

weight to three-and-a-half hundred-weight each. The ash-box forms the base, upon which are mounted the convolutes, from the inside of which all the products of combustion are delivered into the horizontal smoke box at the top, from whence they are conveyed to the chimney direct by the pipe, as shown.

In the front are four doors: The first one, at the end of the "smoke box," can be removed for the purpose of cleaning the box and the necks of the convolutes with the brush (supplied with each stove); the second door, immediately over the fire-clay slabs, allows the upper part of the convolutes to be cleaned with the brush; the third is the fire door; and the fourth the ash-box door, by which the draught can be regulated, though this purpose is more fully answered by the damper in the smoke box.

On reference to the horizontal and cross section (Figs. 46, 47), it will be seen that the convolutes are slightly arched or dome-shaped, each being *deeply grooved* to form a chamber, with an aperture at the top of each arch leading to the smoke box. These grooves extend also down the sides. Each convolute is a separate casting, and *is in itself a moderate-sized stove*; the inner and outer surface being equal. The internal flues of the convolutes act as so many conductors of heat and flame; and the external flues as so many warm air channels, compelling rapid circulation and diffusion, and affording in a small compass a remarkable extent of heating surface. The convolutes are held together by bolts, and are connected by a peculiar hermetical joint (which forms part of the patent) made sound and rendered thoroughly smoke-tight by iron borings or other substances.

In the cross section (Fig. 47), between the fire and the top

of the stove, will be seen slabs of fire-clay, resting loosely on brackets. These slabs equalise the heat in all parts of the stove, and prevent the direct escape of the flame and hot gases into the smoke box and the chimney, by projecting them into the convolutes, and thus concentrating the heating power on the parts where it is of most service.

At each side of the grate, and at the back, the stove is lined with fire brick to the depth of six inches, protecting the metal from immediate contact with the fire, though not preventing the flame and hot gases from entering the convolutes.

In the Convoluted Stove the heating and radiating surface is very large, while the grate space is reduced to the minimum. To each square foot of grate space there is about one hundred feet of radiating surface; with these proportions, the fire-brick lining, and ordinary care, the apparatus can never be injured by the fire.

The engraving (Fig. 48) shows a No. 4 Convoluted Stove with ten convolutes, fixed in brickwork, one side of brickwork omitted to show warm air flues and smoke pipe. The position of apparatus cannot, of course, in all cases be the same as here shown. Frequently it has to be fixed on the same level as the rooms to be heated, especially in country places or on the coast, where excavation is impracticable; from there being no drainage or from the backing up of water at high tide. In Turkish baths especially the apparatus room has frequently to be contrived in an out-of-the-way position and on the same level as the hot rooms.

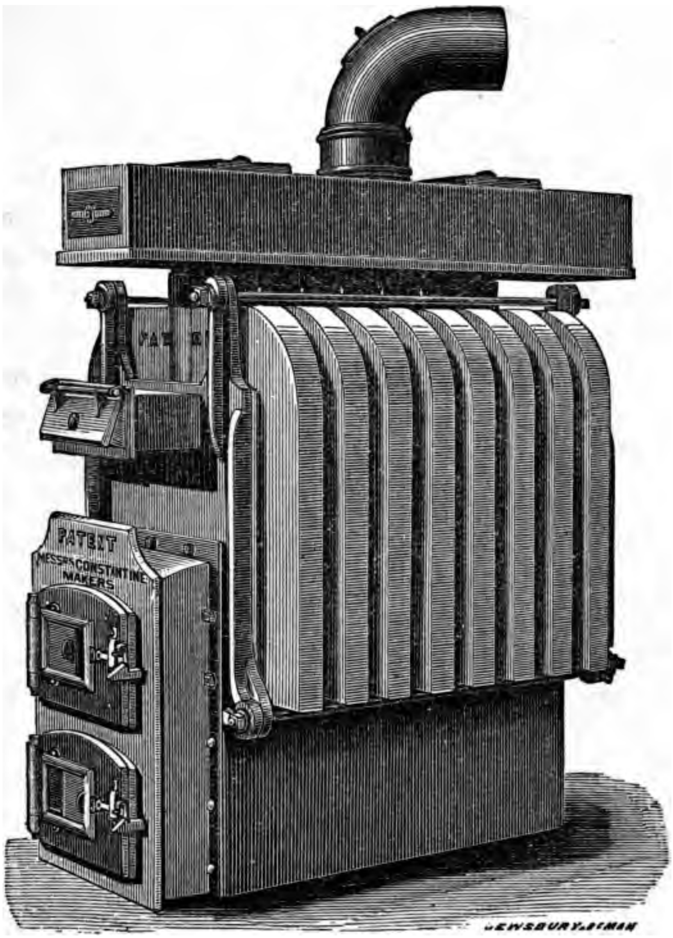


Fig. 44. — Convoluted Stove.

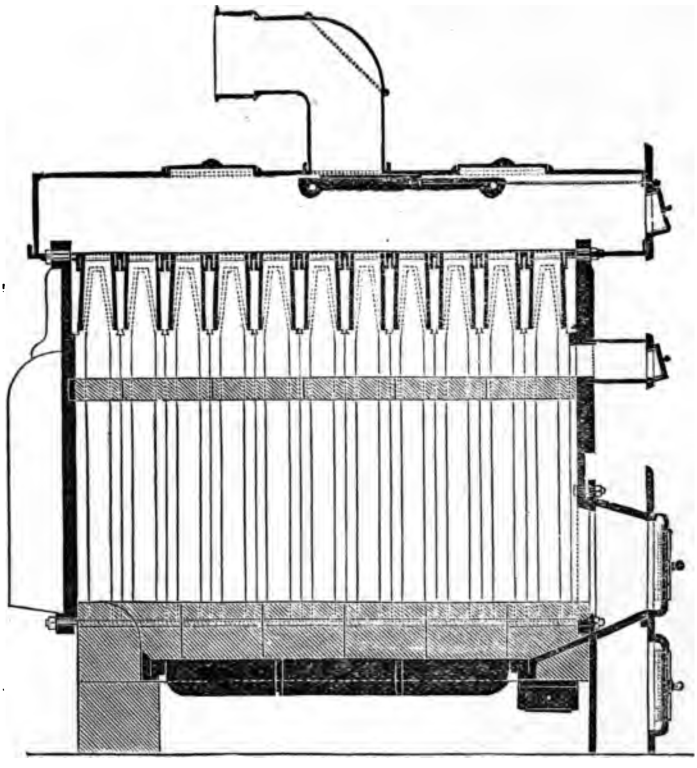


Fig. 45. — Longitudinal Section Convoluted Stove.

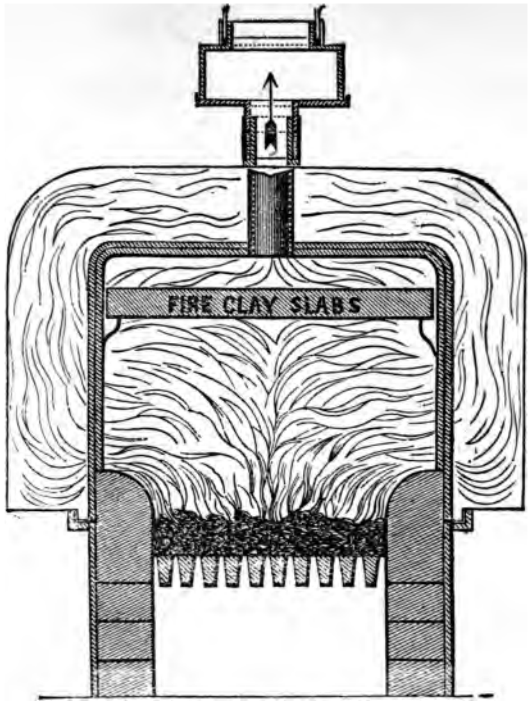


Fig. 46.—HORIZONTAL SECTION.

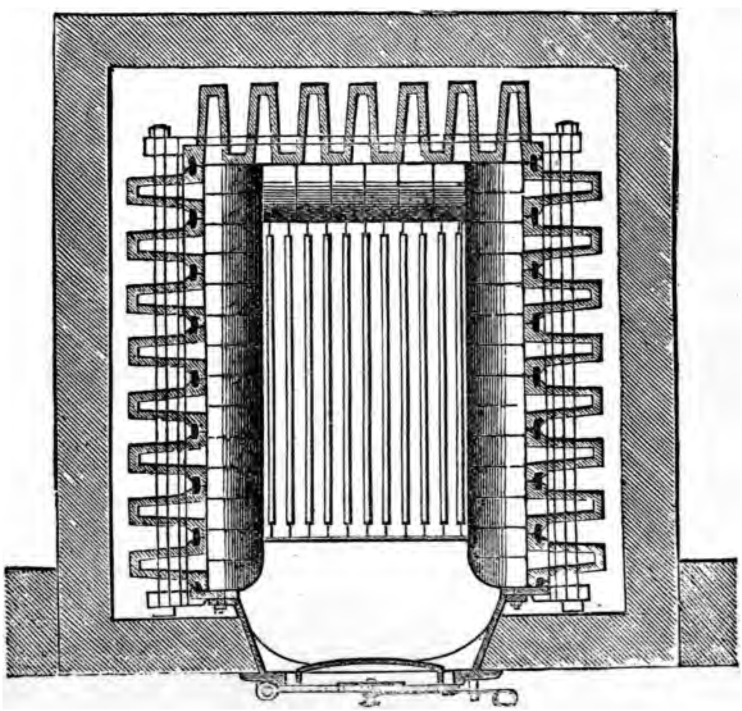


Fig. 47.—CROSS SECTION. CONVOLUTED STOVE.

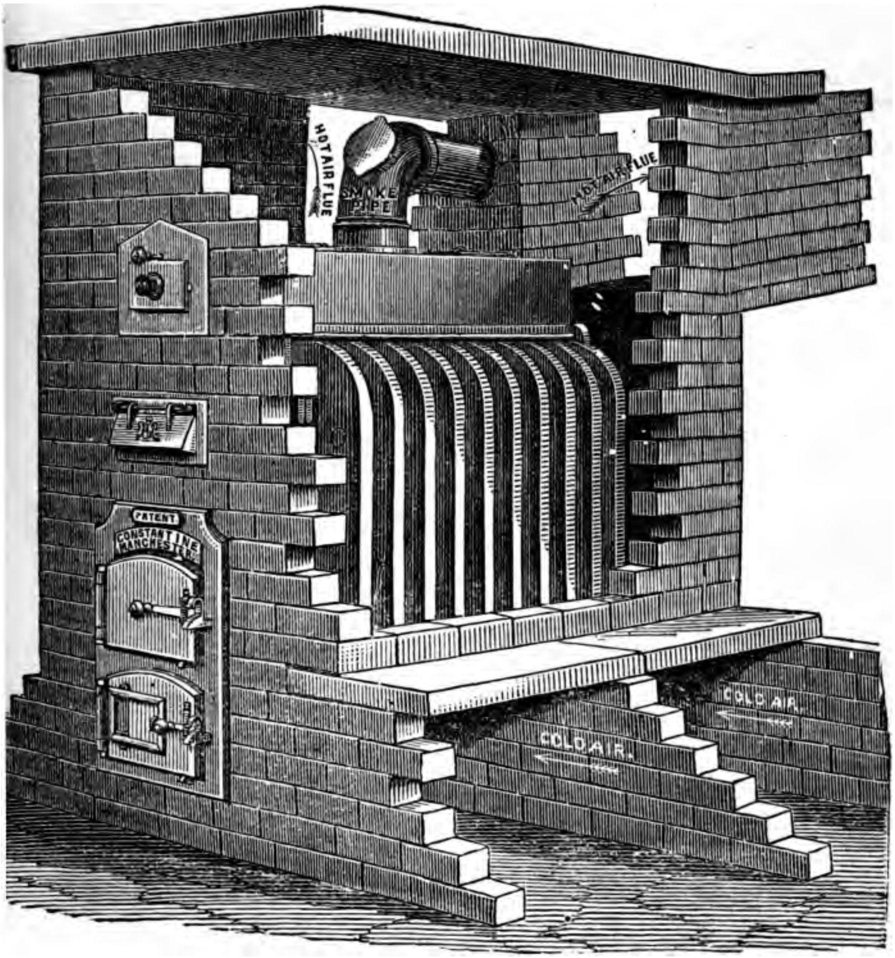


Fig. 48.—CONVOLUTED STOVE IN BRICKWORK.

In the Convoluted Stove with the fire-clay slab running through and filling the upper part of the fire-box, and which throws the flame into the convolutes, the greatest radiation is obtained. The following scale is the result of experience, and may be relied upon for efficient warming without any forcing of the fire, which always means waste of fuel.

Weight of Metal.	Area of Heating Surface.		Area capable of Warming.	Area per Cwt.
cwt.	sq. ft.		cubic feet.	cubic ft.
14	35	=	26,000	1,857
20	55	=	40,000	2,000
22	69	=	50,000	2,275
34	119	=	86,000	2,529
36	139	=	100,000	2,777
45	280	=	140,000	3,111
50	231	=	175,000	3,500
56	296	=	22,000	3,928

It will be seen by the figures on the scale that with the small stove one hundredweight of metal warms an area of 1,857 cubic feet, and that as the stove increases in size a greater result per hundredweight is obtained. The last figures show that one hundredweight warms an area of 3,928 cubic feet. This must not be taken as the minimum weight of metal in each case, but an average.

Failure in Warming large Buildings.

It is most important to notice a frequent cause of *complete failure* in warming Churches and large buildings open to the roof—*i.e.*, without ceiling. Unless the underside of the slates be protected by a layer of felt in addition to boarding, as the hot air thrown into the room at once rises it

opens the joints of the inside boarding and the heat is radiated into outside space from the slating, which is a good conductor of heat.

For the same reason glass buildings can never be heated by hot air. The Crystal Palace is an illustration of this; several large boilers are fixed with an immense quantity of piping (on the low pressure system), but with all efforts the warming is a complete failure, the heat being given off to the surrounding atmosphere as fast as it is generated, and there being a rush of cold air from above as a consequence.

In the construction of Turkish Baths, in which a very high temperature is necessary, we strongly recommend a *plastered ceiling*, with an air space between it and the slating, as well as cavity walls. The layer of air, as well as the lath and plaster work, are good non-conductors of heat, and thus heating power is economised.

Ornamental Stoves.

Great advances have of late years been made in the construction of stoves for offices, shops, and small rooms. Where economy of fuel is an object, as well as the minimum of attention, Messrs. Smith and Wellston of Glasgow, have brought out a number of stoves of ornamental appearance, some of which allow of an open fire if desired. We give engravings of a few of the best, with the maker's own description somewhat abbreviated.

The "International" Stove (Fig. 49) shows the open front fire on three sides of the stove, and with sliding shutters to close in the same at will. Register valve for regulating the heat of the apartment, ash drawer, &c. Smoke collar goes from the back.

The "Sovereign" (Fig. 50.)—This stove is substantial, durable, and handsome. The upper radiating chamber is made of finely polished Siberian iron, and has a revertible flue arrangement, which gives either a direct or circuitous draught current at pleasure, is complete in its operation, and secures efficiency and economy of fuel.

The fire chamber is lined with fire-clay tiles; a copper evaporating pan fits in the scroll top; and with its own ash-pan, cinder-riddle, and fender arrangement, the "Sovereign" is complete in every respect.

Fig. 49.—The "International" Stove.

Fig. 50. — The "Sovereign."

THE "NEW SUN" (Fig. 51.)—A very massive stove, with handsome outline. A powerful radiator, and adapted for the largest apartments or halls, or Railway Station rooms. Constructed so as to allow of expansion of the metal, securing against fracture or cracking. Shaking grate for clearing the ribs without using a poker, preventing dust escaping; also an efficient arrangement for regulating the heat and combustion. Smoke nozzle from the back of stove.

Fig. 51.—"NEW SUN."

THE "BEACON" (Fig. 52.) — A handsome new design, a fine warming stove, suitable for shops, offices, cabins, &c.; accommodation for boiling by lifting off the open work top. A drawing-out ash-pan, a sliding register for regulating the heat, fire-brick linings, &c.

Fig. 52. — "BEACON."

INDEX.

Printed by Charles E. Simms, 53, King Street, Manchester.

Catalogue B]

London, New Burlington Street
March, 1881

SELECTION

FROM

J. & A. CHURCHILL'S GENERAL CATALOGUE

COMPRISING

ALL RECENT WORKS PUBLISHED BY THEM

ON THE

ART AND SCIENCE OF MEDICINE

A SELECTION

FROM

J. & A. CHURCHILL'S GENERAL CATALOGUE,

COMPRISING

ALL RECENT WORKS PUBLISHED BY THEM ON THE ART AND SCIENCE OF MEDICINE.

N.B.—*J. & A. Churchill's Descriptive List of Works on Chemistry, Materia Medica, Pharmacy, Botany, Photography, Zoology, the Microscope, and other Branches of Science, can be had on application.*

The Practice of Surgery:
A Manual. By THOMAS BRYANT, Surgeon to Guy's Hospital. Third Edition. 2 vols. Crown 8vo, with 672 Engravings (many being coloured), 28s.

"Much compactness. . . . . Full of matter well employed and of experience well used. . . . Illustrations good."—*British Medical Journal.*

"It is upon the excellence of much of the clinical teaching to be found in its pages that the success which the book has met with in great measure depends."—*Medical Press and Circular.*

Illustrations of Clinical Surgery.
By JONATHAN HUTCHINSON, Senior Surgeon to the London Hospital. In Quarterly Fasciculi. I. to XIII., 6s. 6d. each. Fasciculi I. to X. bound, with Appendix and Index, £3 10s.

The Principles and Practice of Surgery. By WILLIAM PIRRIE, F.R.S.E., Professor of Surgery in the University of Aberdeen. Third Edition. 8vo, with 490 Engravings, 28s.

A System of Practical Surgery.
By Sir WILLIAM FERGUSSON, Bart., F.R.S. Fifth Edition. 8vo, with 463 Engravings, 21s.

Surgical Emergencies:
Together with the Emergencies Attendant on Parturition and the Treatment of Poisoning. By PAUL SWAIN, F.R.C.S., Surgeon to the Royal Albert Hospital, Devonport. Third Edition. Crown 8vo, with 117 Engravings, 5s.

A Course of Operative Surgery.
By CHRISTOPHER HEATH, Surgeon to University College Hospital. With 20 Plates drawn from Nature by M. LÉVEILLÉ, and coloured by hand under his direction. Large 8vo, 40s.

By the same Author.

The Student's Guide to Surgical Diagnosis. Fcap. 8vo, 6s. 6d.

Also.

Manual of Minor Surgery and Bandaging. For the use of House Surgeons, Dressers, and Junior Practitioners. Sixth Edition. Fcap. 8vo, with 115 Engravings, 5s. 6d.

Also.

Injuries and Diseases of the Jaws. Second Edition. 8vo, with 164 Engravings, 12s.

The Surgeon's Vade-Mecum:
A Manual of Modern Surgery. By ROBERT DRUITT, F.R.C.S. Eleventh Edition. Fcap. 8vo, with 369 Engravings, 14s.

Treatment of Wounds:
Clinical Lectures. By SAMPSON GAMGEE, F.R.S.E., Surgeon to the Queen's Hospital, Birmingham. Crown 8vo, with Engravings, 5s.

By the same Author.

Fractures of the Limbs,
And their Treatment. 8vo, with Plates, 10s. 6d.

Outlines of Surgery and Surgical Pathology. By F. Le Gros Clark, F.R.S., assisted by W. W. Wagstaffe, F.R.C.S. Second Edition. 8vo, 10s. 6d.

Surgical Enquiries: Including the Hastings Essay on Shock, the Treatment of Inflammations, and numerous Clinical Lectures. By Furneaux Jordan, F.R.C.S., Professor of Surgery, Queen's College, Birmingham. Second Edition, with numerous Plates. Royal 8vo, 12s. 6d.

Clinical and Pathological Observations in India. By Sir J. Fayrer, K.C.S.I., M.D. 8vo, with Engravings, 20s.

The Female Pelvic Organs, Their Surgery, Surgical Pathology, and Surgical Anatomy, in a Series of Coloured Plates taken from Nature: with Commentaries, Notes, and Cases. By Henry Savage, Consulting Officer of the Samaritan Free Hospital. Third Edition. 4to, £1 15s.

Transfusion of Human Blood: With Table of 50 cases. By Dr. Roussel, of Geneva. With a Preface by Sir James Paget, Bart. Crown 8vo, 2s. 6d.

Hare-Lip and Cleft Palate. By Francis Mason, F.R.C.S., Surgeon and Lecturer on Anatomy at St. Thomas's Hospital. 8vo, with 66 Engravings, 6s.

By the same Author.

The Surgery of the Face. 8vo, with 100 Engravings, 7s. 6d.

A Practical Treatise on Aural Surgery. By H. Macnaughton Jones, M.D., Professor of the Queen's University in Ireland, Surgeon to the Cork Ophthalmic and Aural Hospital. Crown 8vo, with 46 Engravings, 5s.

By the same Author.

Atlas of Diseases of the Membrana Tympani. In Coloured Plates, containing 62 Figures, with Text. Crown 4to, 21s.

Diseases and Injuries of the Ear. By William B. Dalby, F.R.C.S., Aural Surgeon to, and Lecturer on Surgery at, St. George's Hospital. Second Edition. Fcap. 8vo, with Engravings, 6s. 6d.

The Ear: Its Anatomy, Physiology, and Diseases. By Charles H. Burnett, A.M., M.D., Aural Surgeon to the Presbyterian Hospital, Philadelphia. 8vo, with 87 Engravings, 18s.

Diseases of the Throat and Nose. A Manual. By Morell Mackenzie, M.D. Lond., Senior Physician to the Hospital for Diseases of the Throat and Chest. Vol. I. Diseases of the Pharynx, Larynx, and Trachea. Post 8vo, with 112 Engravings, 12s. 6d.

"There can be but one verdict of the profession on this manual. It stands without any competitor in British medical literature, as a standard work on the organs it professes to treat of."—*Dublin Medical Journal.*

Ear and Throat Diseases. Essays by Llewellyn Thomas, M.D., Surgeon to the Central London Throat and Ear Hospital. Post 8vo, 2s. 6d.

Clubfoot: Its Causes, Pathology, and Treatment. By Wm. Adams, F.R.C.S., Surgeon to the Great Northern Hospital. Second Edition. 8vo, with 106 Engravings and 6 Lithographic Plates, 15s.

By the same Author.

On Contraction of the Fingers, and its Treatment by Subcutaneous Operation; and on Obliteration of Depressed Cicatrices, by the same Method. 8vo, with 30 Engravings, 4s. 6d.

Lectures on Orthopædic Surgery. By Bernard E. Brodhurst, F.R.C.S., Surgeon to the Royal Orthopædic Hospital. Second Edition. 8vo, with Engravings, 12s. 6d.

Osteotomy: With an Enquiry into the Etiology and Pathology of Knock-knee, Bow-leg, and other Osseous Deformities of the Lower Limbs. By William Macewen, M.D., Surgeon and Lecturer on Clinical Surgery to the Glasgow Royal Infirmary. 8vo, with 51 Engravings, 7s. 6d.

Orthopraxy: The Mechanical Treatment of Deformities, Debilities, and Deficiencies of the Human Frame. By H. Heather Bigg, Assoc. Inst. C.E. Third Edition. 8vo, with 319 Engravings, 15s.

The Orthopragms of the Spine: An Essay on the Curative Mechanisms applicable to Spinal Curvature, etc. By Robert Heather Bigg, Assoc. Inst. C.E. 8vo, with Engravings, 5s.

Orthopædic Surgery, And Diseases of the Joints. By Lewis A. Sayre, M.D., Professor of Orthopædic Surgery in Bellevue Hospital Medical College. 8vo, with 274 Engravings, 20s.

Diseases of the Testis, Spermatic Cord, and Scrotum. By THOMAS B. CURLING, F.R.S., Consulting Surgeon to the London Hospital. Fourth Edition. 8vo, with Engravings, 16s.

Fistula, Hæmorrhoids, Painful Ulcer, Stricture, Prolapsus, and other Diseases of the Rectum. By WILLIAM ALLINGHAM, Surgeon to St. Mark's Hospital for Fistula. Third Edition. 8vo, with Engravings, 10s.

Cancer of the Rectum: Its Pathology, Diagnosis, and Treatment. By W. HARRISON CRIPPS, F.R.C.S., Surgeon to the Great Northern Hospital, etc. Crown 8vo, with Lithographic Plates, 6s.

Hydrocele: Its several Varieties and their Treatment. By SAMUEL OSBORN, late Surgical Registrar to St. Thomas's Hospital. Fcap. 8vo, with Engravings, 3s.

By the same Author.

Diseases of the Testis. Fcap. 8vo, with Engravings. 3s. 6d.

Diseases of the Urinary Organs: Clinical Lectures. By Sir HENRY THOMPSON, F.R.C.S., Emeritus Professor of Clinical Surgery in University College. Fifth Edition. 8vo, with 2 Plates and 71 Engravings, 10s. 6d.

"Catholic in his investigation of the fruit of the labour of others, cautious in all his deductions, rejecting all specious theories in the effort to obtain practically useful results, as clever with his pen as he is with the sound or lithotrite, one can scarcely wonder that he is esteemed the master that he is."—*American Journ. of Med. Sci.*

By the same Author.

Diseases of the Prostate: Their Pathology and Treatment. Fourth Edition. 8vo, with numerous Plates, 10s.

Also.

Practical Lithotomy and Lithotrity; or, an Inquiry into the best Modes of Removing Stone from the Bladder. Third Edition. 8vo, with 87 Engravings, 10s.

Also.

The Preventive Treatment of Calculous Disease, and the Use of Solvent Remedies. Second Edition. Fcap. 8vo, 2s. 6d.

Lectures on the Surgical Disorders of the Urinary Organs. By REGINALD HARRISON, F.R.C.S., Surgeon to the Liverpool Royal Infirmary. Second Edition, with 48 Engravings. 8vo. 12s. 6d.

Lithotomy and Extraction Stone. By W. POULETT HAR M.D., Surgeon-Major H.M. Be Medical Service. 8vo, with Engravi 10s. 6d.

The Surgery of the Rectum. By HENRY SMITH, Professor of Sur in King's College, Surgeon to Ki College Hospital. Fourth Edition. F 8vo, 5s.

Diseases of the Bladder, Prostate Gland, and Urethra, wit practical view of Urinary Diseases, posits, and Calculi. By F. J. GA Senior Surgeon to the Royal Free pital. Fourth Edition. Crown 10s. 6d.

Renal and Urinary Diseases Clinical Reports. By WILLIAM CAR M.B., Physician to the Liverpool Sout Hospital. Crown 8vo, 7s. 6d.

The Marriage of Near Kin, Considered with respect to the Law Nations, Results of Experience, and Teachings of Biology. By ALFRE HUTH. 8vo, 14s.

The Reproductive Organs In Childhood, Youth, Adult Age, and vanced Life, considered in their Ph logical, Social, and Moral Relations. WILLIAM ACTON, M.R.C.S. Edition. 8vo, 12s.

Student's Primer on the Uri By J. TRAVIS WHITTAKER, M Clinical Demonstrator at the Royal firmary, Glasgow. With 16 Plates et on Copper. Post 8vo, 4s. 6d.

Urinary and Reproductive gans: their Functional Diseases. D. CAMPBELL BLACK, M.D. Se Edition. 8vo, 10s.

Lectures on Syphilis. By HENRY LEE, Consulting Surgeon t George's Hospital. 8vo, 10s.

Harveian Lectures on Syphi By JAMES R. LANE, F.R.C.S., Su to St. Mary's Hospital. Second Ed Fcap. 8vo, 3s. 6d.

A Treatise on Syphilis. By WALTER J. COULSON, Surgeo the Lock Hospital and to St. P Hospital for Stone. 8vo, 10s.

By the same Author.

Stone in the Bladder: Its Prevention, early Symptoms, Treatment by Lithotrity. 8vo, 6s.

Also.

Coulson on Diseases of Bladder and Prostate Sixth Edition. 8vo, 16s.

Syphilitic Nervous Affections: Their Clinical Aspects. By THOMAS BUZZARD, M.D., F.R.C.P. Physician to the National Hospital for Paralysis and Epilepsy. Post 8vo, 5s.

Pathology of the Urine, Including a Complete Guide to its Analysis. By J. L. W. THUDICHUM, M.D., F.R.C.P. Second Edition, rewritten and enlarged. 8vo, with Engravings, 15s.

Genito-Urinary Organs, including Syphilis: a Practical Treatise on their Surgical Diseases, designed as a Manual for Students and Practitioners. By W. H. VAN BUREN, M.D., and E. L. KEYES, M.D. Royal 8vo, with 140 Engravings, 21s.

Histology and Histo-Chemistry of Man. By HEINRICH FREY, Professor of Medicine in Zurich. Translated by ARTHUR E. J. BARKER, Assistant-Surgeon to University College Hospital. 8vo, with 608 Engravings, 21s.

Principles of Human Physiology. By W. B. CARPENTER, C.B., M.D., F.R.S. Ninth Edition. By HENRY POWER, M.B., F.R.C.S. 8vo, with 3 Steel Plates and 377 Wood Engravings, 31s. 6d.

A Treatise on Human Physiology. By JOHN C. DALTON, M.D., Professor in the College of Physicians and Surgeons, New York. Sixth Edition. Royal 8vo, with 316 Engravings, 20s.

The Spectroscope in Medicine. By CHARLES A. MACMUNN, B.A., M.D. 8vo, with 3 Chromo-lithographic Plates of Physiological and Pathological Spectra, and 13 Engravings, 9s.

"It is painstaking throughout; it aims not at brilliancy but at accuracy; and the result is that we feel we may safely rely on the conclusions of the author."—*Medical Times and Gazette.*

Manual of Anthropometry: A Guide to the Measurement of the Human Body, containing an Anthropometrical Chart and Register, a Systematic Table of Measurements, &c. By CHARLES ROBERTS, F.R.C.S. 8vo, with numerous Illustrations and Tables, 6s. 6d.

The Student's Guide to Human Osteology. By WILLIAM WARWICK WAGSTAFFE, Assistant Surgeon to St. Thomas's Hospital. Fcap. 8vo, with 23 Plates and 66 Engravings, 10s. 6d.

Practical Histology. By WILLIAM RUTHERFORD, M.D., F.R.S. Second Edition. Crown 8vo, *with 63 Engravings, 6s.*

Manual of the Dissection of the Human Body. By LUTHER HOLDEN, Senior Surgeon to St. Bartholomew's and the Foundling Hospitals. Fourth Edition. 8vo, with 170 Engravings, 16s.

By the same Author.

Human Osteology: Sixth Edition. 8vo, with 61 Lithographic Plates and 89 Engravings. (*In the Press.*)

Also.

Landmarks, Medical and Surgical. Second Edition. 8vo, 3s. 6d.

Sanderson's Handbook for the Physiological Laboratory. By E. KLEIN, M.D., F.R.S.; J. BURDON-SANDERSON, M.D., F.R.S.; MICHAEL FOSTER, M.D., F.R.S.; and T. LAUDER BRUNTON, M.D., F.R.S. 8vo, with 123 Plates, 24s.

Text-Book of Physiology. By J. FULTON, M.D., Professor of Physiology, &c., in Trinity Medical College, Toronto. Second Edition. 8vo, with 152 Engravings, 15s.

Lectures on Pathological Anatomy. By SAMUEL WILKS, M.D., F.R.S., Physician to Guy's Hospital; and WALTER MOXON, M.D., Physician to Guy's Hospital. Second Edition. 8vo, with Plates, 18s.

A Manual of Pathological Anatomy. By C. HANDFIELD JONES, M.B., F.R.S.; and EDWARD H. SIEVEKING, M.D., F.R.C.P. Edited (with considerable enlargement) by J. F. PAYNE, M.D., F.R.C.P., Lecturer on General Pathology at St. Thomas's Hospital. Second Edition. Crown 8vo, with 195 Engravings, 16s.

The Student's Guide to Surgical Anatomy: An Introduction to Operative Surgery. By EDWARD BELLAMY, F.R.C.S. and Member of the Board of Examiners. Fcap. 8vo, with 76 Engravings, 7s.

"A text-book which breathes meaning and relational value into the study of human anatomy from the surgical side."—*British Medical Journal.*

"We do not know any book of the kind which will be found so useful to students and to surgeons preparing for the higher examinations."—*Dublin Medical Journal.*

Atlas of Pathological Anatomy. By Dr. LANCEREAUX. Translated by W. S. GREENFIELD, M.D., Assistant Physician to St. Thomas's Hospital, with 70 Coloured Plates. Imp. 8vo, £5 5s.

Practical Anatomy:
A Manual of Dissections. By CHRISTOPHER HEATH, Surgeon to University College Hospital. Fourth Edition. Crown 8vo, with 16 Coloured Plates and 264 Engravings, 14s.

Wilson's Anatomist's Vade-Mecum. Tenth Edition. By GEORGE BUCHANAN, Professor of Clinical Surgery in the University of Glasgow; and HENRY E. CLARK, M.R.C.S., Lecturer on Anatomy at the Glasgow Royal Infirmary School of Medicine. Crown 8vo, with 450 Engravings (including 26 Coloured Plates), 18s.

Braune's Atlas of Topographical Anatomy, after Plane Sections of Frozen Bodies. Translated by EDWARD BELLAMY, Surgeon to, and Lecturer on Anatomy, &c., at, Charing Cross Hospital. Large Imp. 8vo, with 34 Photo-lithographic Plates and 46 Woodcuts, 40s.

An Atlas of Human Anatomy:
By RICKMAN J. GODLEE, M.S., F.R.C.S., Assistant Surgeon and Senior Demonstrator of Anatomy, University College Hospital. With 48 Imp. 4to Plates (112 figures), and a volume of Explanatory Text, 8vo, £4 14s. 6d.

Post-Mortem Examinations:
A Description and Explanation of the Method of performing them, with especial reference to Medico-Legal Practice. By Prof. VIRCHOW. Translated by Dr. T. P. SMITH. Second Edition. Fcap. 8vo, with 4 Plates, 3s. 6d.

Surgical Anatomy:
A Series of Dissections, illustrating the Principal Regions of the Human Body. By JOSEPH MACLISE. Second Edition. 52 folio Plates and Text. Cloth, £3 12s.

By the same Author.

On Dislocations and Fractures.
Uniform with "Surgical Anatomy." 36 folio Plates and Text. Cloth, £2 10s.

Medical Anatomy.
By FRANCIS SIBSON, M.D., F.R.C.P., F.R.S. Imp. folio, with 21 Coloured Plates, cloth, 42s., half-morocco, 50s.

Diagrams of the Nerves of the Human Body, exhibiting their Origin, Divisions, and Connections, with their Distribution to the Various Regions of the Cutaneous Surface, and to all the Muscles. By WILLIAM H. FLOWER, F.R.C.S., F.R.S., Hunterian Professor of Comparative Anatomy, Royal College of Surgeons. Third Edition, with 6 Plates. Royal 4to, 12s.

Anatomy of the Joints of Man.
By HENRY MORRIS, Surgeon to, and Lecturer on Anatomy and Practical Surgery at, the Middlesex Hospital. 8vo, with 44 Lithographic Plates (several being coloured) and 13 Wood Engravings, 16s.

The Anatomical Remembrancer; or, Complete Pocket Anatomist. Eighth Edition. 32mo, 3s. 6d.

The Student's Guide to the Practice of Medicine. By MATTHEW CHARTERIS, M.D., Professor of Materia Medica in the University of Glasgow. Second Edition. Fcap. 8vo, with Engravings on Copper and Wood, 6s. 6d.

The Student's Guide to Medical Diagnosis. By SAMUEL FENWICK, M.D., F.R.C.P., Physician to the London Hospital. Fourth Edition. Fcap. 8vo, with 106 Engravings, 6s. 6d.

By the same Author.

The Student's Outlines of Medical Treatment. Fcap. 8vo, 7s.

Also.

On Chronic Atrophy of the Stomach, and on the Nervous Affections of the Digestive Organs. 8vo, 8s.

The Microscope in Medicine.
By LIONEL S. BEALE, M.B., F.R.S., Physician to King's College Hospital. Fourth Edition. 8vo, with 86 Plates, 21s.

Also.

On Slight Ailments:
Their Nature and Treatment. 8vo, 5s.

A Manual of Medical Diagnosis.
By A. W. BARCLAY, M.D., F.R.C.P., Physician to St. George's Hospital. Third Edition. Fcap. 8vo, 10s. 6d.

Clinical Medicine:
Lectures and Essays. By BALTHAZAR FOSTER, M.D., F.R.C.P. Lond., Professor of Medicine in Queen's College, Birmingham. 8vo, 10s. 6d.

Clinical Lectures and Cases, with Commentaries. By HENRY THOMPSON, M.D., F.R.C.P., Consulting Physician to Middlesex Hospital. With Temperature Charts. 8vo, 7s. 6d.

Clinical Studies:
Illustrated by Cases observed in Hospital and Private Practice. By Sir J. ROSE CORMACK, M.D., F.R.S.E., Physician to the Hertford British Hospital of Paris 2 vols. Post 8vo, 20s.

Relapse of Typhoid Fever, especially with reference to the Temperature. By J. PEARSON IRVINE, M.D., F.R.C.P., late Assistant Physician to Charing Cross Hospital. 8vo, with Engravings, 6s.

Croonian Lectures on Some Points in the Pathology and Treatment of Typhoid Fever. By WILLIAM CAYLEY, M.D., F.R.C.P., Physician to the Middlesex and the London Fever Hospitals. Crown 8vo, 4s. 6d.

A New System of Medicine; Entitled Recognisant Medicine, or the State of the Sick. By BHOLANOTH BOSE, M.D., Indian Medical Service. 8vo, 10s. 6d.

By the same Author.

Principles of Rational Therapeutics. Commenced as an Inquiry into the Relative Value of Quinine and Arsenic in Ague. Crown 8vo, 4s. 6d.

Medicinal Plants: Being descriptions, with original figures, of the Principal Plants employed in Medicine, and an account of their Properties and Uses. By Professor BENTLEY and Dr. H. TRIMEN. In 4 volumes, large 8vo, with 306 Coloured Plates, bound in Half Morocco, Gilt Edges. £11 11s.

Royle's Manual of Materia Medica and Therapeutics. Sixth Edition, by JOHN HARLEY, M.D., Physician to St. Thomas's Hospital. Crown 8vo, with 139 Engravings, 15s.

A Manual of Practical Therapeutics. By E. J. WARING, M.D., F.R.C.P. Lond. Third Edition. Fcap. 8vo, 12s. 6d.

The Student's Guide to Materia Medica. By JOHN C. THOROWGOOD, M.D., F.R.C.P. Lond. Fcap. 8vo, 6s. 6d.

Materia Medica and Therapeutics: Vegetable Kingdom. By CHARLES D. F. PHILLIPS, M.D., Lecturer on Materia Medica and Therapeutics to Westminster Hospital. 8vo, 15s.

The National Dispensatory: Containing the Natural History, Chemistry, Pharmacy, Actions and Uses of Medicines, including those recognised in the Pharmacopœias of the United States and Great Britain and Germany, with numerous references to the French Codex. By ALFRED STILLÉ, M.D., LL.D., and JOHN M. MAISCH, Ph.D. Second Edition. 8vo, with 239 Engravings, 34s.

Binz's Elements of Therapeutics: A Clinical Guide to the Action of Drugs. Translated by EDWARD I. SPARKS, M.B., F.R.C.P. Crown 8vo, 8s. 6d.

The Pharmacopœias of the London Hospitals, arranged in Groups for Easy Reference and Comparison. By PETER SQUIRE, F.L.S., assisted by his sons, P. W. SQUIRE and A. H. SQUIRE. Fourth Edition. 18mo, 6s.

Also.

A Companion to the British Pharmacopœia. Twelfth Edition. 8vo, 10s. 6d.

Dental Materia Medica and Therapeutics. By JAMES STOCKEN, L.D.S.R.C.S., late Lecturer to the National Dental Hospital. Second Edition. Fcap. 8vo, 6s. 6d.

The Wasting Diseases of Children. By EUSTACE SMITH, M.D., Physician to the King of the Belgians, Physician to the East London Hospital for Children. Third Edition. Post 8vo, 8s. 6d.

By the same Author.

Clinical Studies of Disease in Children. Post 8vo, 7s. 6d.

Infant Feeding and its Influence on Life; or, the Causes and Prevention of Infant Mortality. By C. H. F. ROUTH, M.D., Senior Physician to the Samaritan Hospital. Third Edition. Fcap. 8vo, 7s. 6d.

A Manual of what every Mother should know. By EDWARD ELLIS, M.D., Author of "A Practical Manual of the Diseases of Children." Fcap. 8vo, 1s. 6d.

The Student's Guide to the Practice of Midwifery. By D. LLOYD ROBERTS, M.D., F.R.C.P., Physician to St. Mary's Hospital, Manchester. Second Edition. Fcap. 8vo, with 111 Engravings, 7s.

Handbook of Midwifery for Midwives: from the Official Handbook for Prussian Midwives. By J. E. BURTON, L.R.C.P. Lond., Senior Assistant Medical Officer, Ladies' Charity, &c., Liverpool. With Engravings. Fcap. 8vo, 6s.

Obstetric Medicine and Surgery: Their Principles and Practice. By F. H. RAMSBOTHAM, M.D., F.R.C.P. Fifth Edition. 8vo, with 120 Plates, 22s.

Lectures on Obstetric Operations: Including the Treatment of Hæmorrhage, and forming a Guide to the Management of Difficult Labour. By ROBERT BARNES, M.D., F.R.C.P., Obstetric Physician to St. George's Hospital. Third Edition. 8vo, with 124 Engravings, 18s.

By the same Author.

A Clinical History of Medical and Surgical Diseases of Women. Second Edition. 8vo, with 181 Engravings, 28s.

West on the Diseases of Women. Fourth Edition, revised and in part re-written by the Author, with numerous Additions by J. MATTHEWS DUNCAN, M.D., Obstetric Physician to St. Bartholomew's Hospital. 8vo, 16s.

Observations on the Cæsarian Section, Craniotomy, and on other Obstetric Operations, with Cases. By THOMAS RADFORD, M.D., Honorary Consulting Physician, St. Mary's Hospital, Manchester. Second Edition, with Plates. 8vo, 10s.

Clinical Lectures on Diseases of Women: Delivered in St. Bartholomew's Hospital, by J. MATTHEWS DUNCAN, M.D., F.R.S.E. 8vo, 8s.

By the same Author.

Papers on the Female Perineum, &c. 8vo, 6s.

The Principles and Practice of Gynæcology. By THOMAS ADDIS EMMET, M.D., Surgeon to the Woman's Hospital, New York. Second Edition. Royal 8vo, with 133 Engravings, 24s.

"The work teems with original ideas, fresh and valuable methods of practice, and is written in a clear and elegant style."—*British Medical Journal.*

The Student's Guide to the Diseases of Women. By ALFRED L. GALABIN, M.D., F.R.C.P., Assistant Obstetric Physician to Guy's Hospital. Second Edition. Fcap. 8vo, with many Engravings, 7s. 6d.

Notes on the Diseases of Women. Specially designed for Students Preparing for Examination. By J. J. REYNOLDS, M.R.C.S. Fcap. 8vo, 2s. 6d.

Practical Gynæcology: A Handbook of the Diseases of Women. By HEYWOOD SMITH, M.D. Oxon., Physician to the Hospital for Women and to the British Lying-in Hospital. Crown 8vo, with Engravings, 5s. 6d.

Obstetric Aphorisms: For the Use of Students commencing Midwifery Practice. By JOSEPH G. SWAYNE, M.D. Seventh Edition. Fcap. 8vo, with Engravings, 3s. 6d.

A Complete Handbook of Obstetric Surgery. Giving Short Rules of Practice in every Emergency. By CHARLES CLAY, late Senior Surgeon to St. Mary's Hospital, Manchester. Third Edition. Fcap. 8vo, with 91 Engravings, 6s. 6d.

Schroeder's Manual of Midwifery, including the Pathology of Pregnancy and the Puerperal State. Translated by CHARLES H. CARTER, B.A., M.D. 8vo, with Engravings, 12s. 6d.

Diseases of the Ovaries: Their Diagnosis and Treatment. By T. SPENCER WELLS, F.R.C.S., Consulting Surgeon to the Samaritan Hospital. 8vo, with about 150 Engravings, 21s.

A Handbook of Uterine Therapeutics, and of Diseases of Women. By E. J. TILT, M.D., M.R.C.P. Fourth Edition. Post 8vo, 10s.

By the same Author.

The Change of Life In Health and Disease: a Practical Treatise on the Nervous and other Affections incidental to Women at the Decline of Life. Third Edition. 8vo, 10s. 6d.

Rupture of the Female Perineum: Its Treatment, immediate and remote. By GEORGE G. BANTOCK, M.D., Surgeon to the Samaritan Hospital. 8vo, with 2 Plates, 3s. 6d.

Influence of Posture on Women in Gynecic and Obstetric Practice. By J. H. AVELING, M.D., Physician to the Chelsea Hospital for Women. 8vo, 6s.

A Manual for Hospital Nurses and others engaged in Attending on the Sick. By EDWARD J. DOMVILLE, Surgeon to the Exeter Lying-in Charity. Third Edition. Crown 8vo, 2s. 6d.

The Nurse's Companion: A Manual of General and Monthly Nursing. By CHARLES J. CULLINGWORTH, Surgeon to St. Mary's Hospital, Manchester. Fcap. 8vo, 2s. 6d.

Lectures on Nursing. By W. R. SMITH, M.B., Physician to the Cheltenham Dispensary. Second Edition. Post 8vo, with 26 Engravings, 6s.

Handbook for Nurses for the Sick. By ZEPHERINA P. VEITCH. Second Edition. Crown 8vo, 3s. 6d.

Notes on Fever Nursing.
By J. W. ALLAN, M.B., Superintendent and Physician, City of Glasgow Fever Hospital. Crown 8vo, with Engravings, 2s. 6d.

Chronic Disease of the Heart:
Its Bearings upon Pregnancy, Parturition, and Childbed. By ANGUS MACDONALD, M.D., F.R.S.E., Physician to the Edinburgh Royal Infirmary. 8vo, with Engravings, 8s. 6d.

Asthma:
Its Pathology and Treatment. By J. B. BERKART, M.D., Assistant-Physician to the City of London Hospital for Diseases of the Chest. 8vo, 7s. 6d.

Pay Hospitals and Paying Wards throughout the World.
By HENRY C. BURDETT, Secretary to the Seamen's Hospital Society. 8vo, 7s.

"Clearly and pleasantly written: full of facts, and contains many valuable suggestions."—*British Medical Journal.*

By the same Author.

Cottage Hospitals — General, Fever, and Convalescent: Their Progress, Management, and Work. Second Edition, with many Plans and Illustrations. Crown 8vo, 14s.

Notes on Asthma:
Its Forms and Treatment. By JOHN C. THOROWGOOD, M.D., Physician to the Hospital for Diseases of the Chest, Victoria Park. Third Edition. Crown 8vo, 4s. 6d.

Observations on the Result of Treatment of nearly One Hundred Cases of Asthma. By T. L. PRIDHAM, M.R.C.S. Third Edition. 8vo, 2s. 6d.

Diseases of the Chest:
Contributions to their Clinical History, Pathology, and Treatment. By A. T. HOUGHTON WATERS, M.D., Physician to the Liverpool Royal Infirmary. Second Edition. 8vo, with Plates, 15s.

Winter Cough:
(Catarrh, Bronchitis, Emphysema, Asthma). By HORACE DOBELL, M.D., Consulting Physician to the Royal Hospital for Diseases of the Chest. Third Edition. 8vo, with Coloured Plates, 10s. 6d.

By the same Author.

Loss of Weight, Blood-Spitting, and Lung Disease. Second Edition, to which is added Part VI., "On the Functions and Diseases of the Liver." 8vo, with Chromo-lithograph, 10s. 6d.

The Ocean as a Health Resort:
A Handbook of Practical Information as to Sea Voyages, for the use of Tourists and Invalids. By WILLIAM S. WILSON, L.R.C.P., with Chart of Ocean Routes, &c. Crown 8vo, 7s. 6d.

Prognosis in Cases of Valvular Diseases of the Heart. By THOMAS B. PEACOCK, M.D., F.R.C.P., Honorary Consulting Physician to St. Thomas's Hospital. 8vo, 3s. 6d.

Clinical Medicine:
A Systematic Treatise on the Diagnosis and Treatment of Disease. By AUSTIN FLINT, M.D., Professor of Medicine in the Bellevue Hospital Medical College. 8vo, 20s.

"We strongly recommend his text-book as not only the most recent but the most complete hitherto published on clinical medicine."—*Dublin Medical Journal.*

By the same Author.

Phthisis:
In a series of Clinical Studies. 8vo, 16s.

Diphtheria:
Its Nature and Treatment, Varieties, and Local Expressions. By MORELL MACKENZIE, M.D., Physician to the Hospital for Diseases of the Throat. 8vo, 5s.

Manual of the Physical Diagnosis of Diseases of the Heart, including the use of the Sphygmograph and Cardiograph. By ARTHUR E. SANSOM, M.D., F.R.C.P., Assistant-Physician to the London Hospital. Third Edition. Fcap. 8vo, with 48 Engravings, 7s. 6d.

By the same Author.

The Antiseptic System in Medicine and Surgery: A Treatise on Carbolic Acid and its Compounds, etc. With 9 Plates (42 Figures), 8vo, 10s. 6d.

Tracheotomy,
Especially in Relation to Diseases of the Larynx and Trachea. By PUGIN THORNTON, late Surgeon to the Hospital for Diseases of the Throat. 8vo, with Photographic Plates and Woodcuts, 5s. 6d.

Lectures on Syphilis of the Larynx (Lesions of the Secondary and Intermediate Stages). By W. MACNEILL WHISTLER, M.D., Physician to the Hospital for Diseases of the Throat and Chest. Post 8vo, 4s.

Sore Throat:
Its Nature, Varieties, and Treatment. By PROSSER JAMES, M.D., Physician to the Hospital for Diseases of the Throat. Fourth Edition. Post 8vo, with Coloured Plates and Engravings, 6s. 6d.

A Treatise on Vocal Physiology and Hygiene, with especial reference to the Cultivation and Preservation of the Voice. By GORDON HOLMES, L.R.C.P. Edin., Physician to the Municipal Throat and Ear Infirmary. Second Edition. With Engravings. Crown 8vo, 6s. 6d.

Principal Health Resorts
Of Europe and Africa, and their Use in the Treatment of Chronic Diseases. By THOMAS MORE MADDEN, M.D., M.R.I.A. 8vo, 10s.

The Riviera:
Sketches of the Health Resorts of the North Mediterranean Coast of France and Italy, from Hyères to Spezia; with Chapters on the General Meteorology of the District, its Medical Aspect and Value, &c. By EDWARD I. SPARKS, M.B., F.R.C.P. Crown 8vo, 8s. 6d.

"He has spared no pains in making his book as comprehensive and accurate as possible."—*Edinburgh Medical Journal.*

"We do not know any work on the subject which more completely supplies all that varied information which it is so important for any one to have who for the first time visits the Riviera as a patient. It often happens that a physician suddenly orders an invalid to be sent there without loss of time. The patient and his friends alike know nothing of the place, and nothing of the best means of making the journey. In Dr. Sparks's volume they will find all the information they require."—*Pall Mall Gazette.*

Winter and Spring
On the Shores of the Mediterranean. By HENRY BENNET, M.D. Fifth Edition. Post 8vo, with numerous Plates, Maps, and Engravings, 12s. 6d.

By the same Author.

Treatment of Pulmonary Consumption by Hygiene, Climate, and Medicine. Third Edition. 8vo, 7s. 6d.

Family Medicine for India:
By WILLIAM J. MOORE, M.D. Published under the Authority of the Government of India. Third Edition. Post 8vo, with 66 Engravings, 12s.

The Elements of Indian Hygiene.
Intended to guide the Public in acquiring some knowledge in the all-important subject of the Preservation of Health and Prevention of Sickness. By JOHN C. LUCAS, F.R.C.S., H.M.'s Indian Medical Service. Crown 8vo, with Map of India, &c., 5s.

Bazaar Medicines of India,
And Common Medical Plants: With Full Index of Diseases, indicating their Treatment by these and other Agents procurable throughout India, &c. By E. J. WARING, M.D., F.R.C.P. Third Edition. Fcap. 8vo, 5s.

Indian Notes.
The Voyage out; Travelling in India; Upper India; Stations; The Hills; Mineral Waters; Herbs and Simples. By F. R. HOGG, M.D., Surgeon-Major. Crown 8vo, 5s.

Diseases of Tropical Climates,
And their Treatment: with Hints for the Preservation of Health in the Tropics. By JAMES A. HORTON, M.D., Surgeon-Major. Second Edition. Post 8vo, 12s. 6d.

Endemic Diseases of Tropical Climates, with their Treatment. By JOHN SULLIVAN, M.D. Post 8vo, 6s.

Diseases of the Stomach:
The Varieties of Dyspepsia, their Diagnosis and Treatment. By S. O. HABERSHON, M.D., F.R.C.P., late Senior Physician to Guy's Hospital. Third Edition. Crown 8vo, 5s.

By the same Author.

Pathology of the Pneumogastric Nerve, being the Lumleian Lectures for 1876. Post 8vo, 3s. 6d.

Also.

Diseases of the Abdomen,
Comprising those of the Stomach and other parts of the Alimentary Canal, Œsophagus, Cæcum, Intestines, and Peritoneum. Third Edition. 8vo, with 5 Plates, 21s.

Studies on Functional Nervous Disorders. By C. HANDFIELD JONES, M.B., F.R.S., Physician to St. Mary's Hospital. Second Edition. 8vo, 18s.

Headaches:
Their Nature, Causes, and Treatment. By WILLIAM H. DAY, M.D., Physician to the Samaritan Hospital for Women and Children. Third Edition. Crown 8vo, with Engravings, 6s. 6d.

Fits:
Diagnosis and Immediate Treatment of Cases of Insensibility and Convulsions. By JOHN H. WATERS, M.D., K.C., St.G.C., Surgeon to the C Division of Metropolitan Police. Crown 8vo, bound in leather, 4s.

Nervous Diseases:
Their Description and Treatment. By ALLEN MCLANE HAMILTON, M.D., Physician at the Epileptic and Paralytic Hospital, Blackwell's Island, New York. Royal 8vo, with 53 Illustrations, 14s.

Lectures on Diseases of the Nervous System. By SAMUEL WILKS, M.D., F.R.S., Physician to, and Lecturer on Medicine at, Guy's Hospital. 8vo, 15s.

On Megrim, Sick Headache and some Allied Disorders: a Contribution to the Pathology of Nerve Storms. By EDWARD LIVEING, M.D., F.R.C.P. 8vo, 15s.

Nutrition in Health and Disease:
A Contribution to Hygiene and to Clinical Medicine. By HENRY BENNET, M.D. Third (Library) Edition. 8vo, 7s. Cheap Edition (Second Thousand). Fcap. 8vo, 2s. 6d.

Food and Dietetics,
Physiologically and Therapeutically Considered. By F. W. PAVY, M.D., F.R.S., Physician to Guy's Hospital. Second Edition. 8vo, 15s.

By the same Author.

Croonian Lectures on Certain Points connected with Diabetes. 8vo, 4s. 6d.

Imperfect Digestion:
Its Causes and Treatment. By ARTHUR LEARED, M.D., F.R.C.P. Sixth Edition. Fcap. 8vo, 4s. 6d.

The Sympathetic System of Nerves: Their Physiology and Pathology. By Professor EULENBURG and Dr. P. GUTTMANN. Translated by A. NAPIER, M.D., F.F.P.S. 8vo, 5s.

Gout, Rheumatism,
And the Allied Affections; with a Chapter on Longevity and the Causes Antagonistic to it. By PETER HOOD, M.D. Second Edition. Crown 8vo, 10s. 6d.

Notes on Rheumatism.
By JULIUS POLLOCK, M.D., F.R.C.P., Senior Physician to the Charing Cross Hospital. Second Edition. Fcap. 8vo, with Engravings, 3s. 6d.

Lectures on Dermatology:
Delivered at the Royal College of Surgeons, by ERASMUS WILSON, F.R.C.S., F.R.S. 1870, 6s.; 1871–73, 10s. 6d.; *1874–75, 10s. 6d.*; 1876–78, 10s. 6d.

Parasites:
A Treatise on the Entozoa of Man and Animals, including some Account of the Ectozoa. By T. SPENCER COBBOLD, M.D., F.R.S. 8vo, with 85 Engravings, 15s.

"The work fixes the reader by the complete mastery of the subject displayed by the author, and by the ever-strange and increasing interest of its several details."—*Lancet.*

"The most complete and most important treatise on entozoa accessible to the English reader."—*Medical Press and Circular.*

Atlas of Skin Diseases:
By TILBURY FOX, M.D., F.R.C.P. With 72 Coloured Plates. Royal 4to, half morocco, £6 6s.

Eczema:
By MCCALL ANDERSON, M.D., Professor of Clinical Medicine in the University of Glasgow. Third Edition. 8vo, with Engravings, 7s. 6d.

Psoriasis, or Lepra.
By GEORGE GASKOIN, M.R.C.S., Surgeon to the British Hospital for Diseases of the Skin. 8vo, 5s.

On Certain Rare Diseases of the Skin: being Vol. 1 of "Lectures on Clinical Surgery." By JONATHAN HUTCHINSON, Senior Surgeon to the London Hospital, and to the Hospital for Diseases of the Skin. 8vo, 10s. 6d.

Certain Forms of Cancer,
With a New and Successful Mode of treating it. By ALEX. MARSDEN, Senior Surgeon to the Cancer Hospital. Second Edition. 8vo, with Coloured Plates, 8s. 6d.

Cancer Life:
Its Causes, Progress, and Treatment. A General and Historical Treatise. By ROBERT MITCHELL, M.R.C.S. 8vo, 7s. 6d.

A Manual of the Laws affecting Medical Men. By ROBERT G. GLENN, LL.B., Barrister-at-Law. 8vo, 14s.

The Medical Adviser in Life Assurance. By EDWARD H. SIEVEKING, M.D., F.R.C.P., Physician to St. Mary's and Lock Hospitals, &c. Crown 8vo, 6s.

Madness:
In its Medical, Legal, and Social Aspects. Lectures by EDGAR SHEPPARD, M.D., M.R.C.P., Professor of Psychological Medicine in King's College. 8vo, 6s. 6d.

Medical Jurisprudence: Its Principles and Practice. By ALFRED S. TAYLOR, M.D., F.R.C.P., F.R.S. Second Edition. 2 vols. 8vo, with 189 Engravings, £1 11s. 6d.

By the same Author.

A Manual of Medical Jurisprudence. Tenth Edition. Crown 8vo, with 55 Engravings, 14s.

Also.

Poisons, In Relation to Medical Jurisprudence and Medicine. Third Edition. Crown 8vo, with 104 Engravings, 16s.

Lectures on Medical Jurisprudence. By FRANCIS OGSTON, M.D., Professor in the University of Aberdeen. Edited by FRANCIS OGSTON, JUN., M.D. 8vo, with 12 Copper Plates, 18s.

A Manual of Psychological Medicine: With an Appendix of Cases. By JOHN C. BUCKNILL, M.D., F.R.S., and D. HACK TUKE, M.D., F.R.C.P. Fourth Edition. 8vo, with 12 Plates (30 Figures) and Engravings, 25s.

Medical Ophthalmoscopy: A Manual and Atlas. By WILLIAM R. GOWERS, M.D., F.R.C.P., Assistant Professor of Clinical Medicine and Physician to the National Hospital for the Paralysed and Epileptic. With 16 Coloured Autotype and Lithographic Plates, and Woodcuts, comprising 112 Original Illustrations of the Changes in the Eye in Diseases of the Brain, Kidneys, &c. 8vo, 18s.

By the same Author.

Pseudo-Hypertrophic Muscular Paralysis: A Clinical Lecture. 8vo, with Engravings and Plate, 3s. 6d.

Also.

The Diagnosis of Diseases of the Spinal Cord. 8vo, with Coloured Plate and Engravings, 4s. 6d.

Idiocy and Imbecility. By WILLIAM W. IRELAND, M.D., Medical Superintendent of the Scottish National Institution for the Education of Imbecile Children at Larbert, Stirlingshire. 8vo, with Engravings, 14s.

A Handy-Book of Forensic Medicine and Toxicology. By W. BATHURST WOODMAN, M.D., F.R.C.P., and C. MEYMOTT TIDY, M.D., F.C.S. 8vo, with 8 Lithographic Plates and 116 Engravings, 31s. 6d.

A Manual of Practical Hygiene. By E. A. PARKES, M.D., F.R.S. Fifth Edition. By F. DE CHAUMONT, M.D., F.R.S., Professor of Military Hygiene in the Army Medical School. 8vo, with 9 Plates and 112 Engravings, 18s.

Sanitary Examinations Of Water, Air, and Food. A Vade-Mecum for the Medical Officer of Health. By CORNELIUS B. FOX, M.D., F.R.C.P. Crown 8vo, with 94 Engravings, 12s. 6d.

Dangers to Health: A Pictorial Guide to Domestic Sanitary Defects. By T. PRIDGIN TEALE, M.A., Surgeon to the Leeds General Infirmary. Second Edition. 8vo, with 55 Lithograph Plates (mostly coloured), 10s.

Microscopical Examination of Drinking Water. By JOHN D. MACDONALD, M.D., F.R.S., Assistant Professor in the Army Medical School. 8vo, with 24 Plates, 7s. 6d.

A Handbook of Hygiene and Sanitary Science. By GEO. WILSON, M.A., M.D., Medical Officer of Health for Mid-Warwickshire. Fourth Edition. Post 8vo, with Engravings, 10s. 6d.

Also.

Healthy Life and Healthy Dwellings: A Guide to Personal and Domestic Hygiene. Fcap. 8vo, 5s.

CHAP. 1, Introductory; 2, The Human Body; 3, Causes of Disease; 4, Food and Diet; 5, Cleanliness and Clothing; 6, Exercise, Recreation, and Training; 7, The House and its Surroundings; 8, Infectious Diseases and their Prevention.

Dress: Its Sanitary Aspect. A Paper read before the Brighton Social Union, Jan. 30, 1880. By BERNARD ROTH, F.R.C.S. 8vo, with 8 Plates, 2s.

Handbook of Medical and Surgical Electricity. By HERBERT TIBBITS, M.D., F.R.C.P.E., Senior Physician to the West London Hospital for Paralysis and Epilepsy. Second Edition. 8vo, with 95 Engravings, 9s.

By the same Author.

A Map of Ziemssen's Motor Points of the Human Body: A Guide to Localised Electrisation. Mounted on Rollers, 35 × 21. With 20 Illustrations, 5s.

Lectures on the Clinical Uses of Electricity. By J. RUSSELL REYNOLDS, M.D., F.R.S., Physician to University College Hospital. Second Edition. Post 8vo, 3s. 6d.

The Student's Guide to Diseases of the Eye. By EDWARD NETTLESHIP, F.R.C.S., Ophthalmic Surgeon to, and Lecturer on Ophthalmic Surgery at, St. Thomas's Hospital. Fcap. 8vo, with 48 Engravings, 7s. 6d.

"It is clear, concise, and thoroughly scientific." —*British Medical Journal.*

"A thoroughly good manual. It is clear, accurate, and scientific, and will prove of great value." —*London Medical Record.*

A Manual of the Principles and Practice of Ophthalmic Medicine and Surgery. By T. WHARTON JONES, F.R.C.S., F.R.S. Third Edition. Fcap. 8vo, with 9 Coloured Plates and 173 Engravings, 12s. 6d.

A Manual of Diseases of the Eye. By C. MACNAMARA, F.R.C.S., Surgeon to Westminster Hospital. Third Edition. Fcap. 8vo, with Coloured Plates and Engravings, 12s. 6d.

Diseases of the Eye: By HAYNES WALTON, F.R.C.S., Surgeon to St. Mary's Hospital and in charge of its Ophthalmological Department. Third Edition. 8vo, with 3 Plates and nearly 300 Engravings, 25s.

Hints on Ophthalmic Out-Patient Practice. By CHARLES HIGGENS, Ophthalmic Assistant-Surgeon to, and Lecturer on Ophthalmology at, Guy's Hospital. Second Edition. Fcap. 8vo, 3s.

Glaucoma: Its Causes, Symptoms, Pathology, and Treatment. By PRIESTLEY SMITH, M.R.C.S., Ophthalmic Surgeon to the Queen's Hospital, Birmingham. 8vo, with Lithographic Plates (comprising 58 Figures), 10s. 6d.

"A brilliant contribution to ophthalmology, of which British surgery may be justly proud."— *Birmingham Medical Review.*

Essays in Ophthalmology. By GEORGE E. WALKER, F.R.C.S., Surgeon to St. Paul's Eye and Ear Hospital, &c., Liverpool. Post 8vo, 6s.

Liebreich's Atlas of Ophthalmoscopy: Composed of 12 Chromolithographic Plates (containing 59 Figures). The Text translated by H. ROSBOROUGH SWANZY, M.B. Second Edition. 4to, 30s.

A Manual of Ophthalmoscopy for the use of Students. By DR. DAGUENET. Translated by C. S. JEAFFRESON, Surgeon to the Newcastle-on-Tyne Eye Infirmary. With Engravings. Fcap. 8vo, 5s.

A System of Dental Surgery. By JOHN TOMES, F.R.S., and CHARLES S. TOMES, M.A., F.R.S. Second Edition. Fcap. 8vo, with 268 Engravings, 14s.

Dental Anatomy, Human and Comparative: a Manual. By CHARLES S. TOMES, M.A., F.R.S. Second Edition. Crown 8vo, with many Engravings. [*In the Press.*

A Manual of Dental Mechanics. By OAKLEY COLES, L.D.S.R.C.S., Surgeon-Dentist to the Hospital for Diseases of the Throat. Second Edition. Crown 8vo, with 140 Engravings, 7s. 6d.

The Student's Guide to Dental Anatomy and Surgery. By HENRY SEWILL, M.R.C.S., L.D.S. Fcap. 8vo, with 77 Engravings, 5s. 6d.

A Practical Treatise on Operative Dentistry. By JONATHAN TAFT, D.D.S., Professor in the Ohio College of Dental Surgery. Third Edition. With 134 Engravings. 8vo, 18s.

A Dictionary of Medical Science: Containing a concise Explanation of the various Subjects and Terms of Medicine, &c.; Notices of Climate and Mineral Waters; Formulæ for Officinal, Empirical, and Dietetic Preparations; with the Accentuation and Etymology of the Terms, and the French and other Synonyms. By ROBLEY DUNGLISON, M.D., LL.D. New Edition. Royal 8vo, 28s.

A Medical Vocabulary: Being an Explanation of all Terms and Phrases used in the various Departments of Medical Science and Practice, giving their Derivation, Meaning, Application, and Pronunciation. By ROBERT G. MAYNE, M.D., LL.D. Fourth Edition. Fcap. 8vo, 10s.

Abridged Medical Account Books. The "Expedite" Method. By JAMES MACNAB, L.R.C.S.E. *Index Ledger.* Royal 4to. For one year, 5s. 6d.; for four years, 21s. *Visiting List.* Cloth, 2s. 6d.; Leather, 3s. 6d.

Medical Education And Practice in all parts of the World. By HERBERT JUNIUS HARDWICKE, M.D., M.R.C.P. 8vo, 10s.

"Dr. Hardwicke's book will prove a valuable source of information to those who may desire to know the conditions upon which medical practice is or may be pursued in any or every country of the world, even to the remotest corners of the earth. The work has been compiled with great care, and must have required a vast amount of labour and perseverance on the part of its author." —*Dublin Medical Journal.*

INDEX TO J. & A. CHURCHILL'S CATALOGUE.

(Continued on the next p